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Pope. attempt at establishing the text of the mighty poet, Pope obtained but little money, and still less reputation. He received, according to tradition, only L.217. 12s. for his trouble of collation, which must have been considerable, and some other trifling editorial labour. And the opinion of all judges, from the first so unfavourable as to have depreciated the money-value of the book enormously, perhaps from a prepossession of the public mind against the fitness of Pope for executing the dull labours of revision, has ever since pronounced this work the very worst edition in existence. For the edition we have little to plead; but for the editor it is but just to make three apologies. In the *first* place, he wrote a brilliant preface, which, although (like other works of the same class) too much occupied in displaying his own ability, and too often, for the sake of an effective antithesis, doing deep injustice to Shakspeare, yet undoubtedly, as a whole, extended his fame, by giving the sanction and countersign of a great wit to the national admiration. *Secondly*, as Dr Johnson admits, Pope's failure pointed out the right road to his successors. *Thirdly*, even in this failure it is but fair to say, that in a graduated scale of merit, as distributed amongst the long succession of editors through that century, Pope holds a rank proportionable to his age. For the year 1720, he is no otherwise below Theobald, Hanmer, Capell, Warburton, or even Johnson, than as they are successively below each other, and all of them as to accuracy below Steevens, as he again was below Malone and Read.

The gains from Shakspeare would hardly counterbalance the loss which Pope sustained this year from the South Sea bubble. One thing, by the way, is still unaccountably neglected by writers on this question: how it was that the great Mississippi bubble, during the Orleans regency in Paris, should have happened to coincide with that of London. If this were accident, how marvellous that the same insanity should possess the two great capitals of Christendom in the same year? If, again, it were not accident, but due to some common cause, why is not that cause explained? Pope to his nearest friends never stated the amount of his loss. The biographers report that at one time his stock was worth from twenty to thirty thousand pounds. But that is quite impossible. It is true, that as the stock rose at one time a thousand per cent., this would not imply on Pope's part an original purchase beyond twenty-five hundred pounds or thereabouts. But Pope has furnished an argument against *that*, which we shall improve. He quotes, more than once, as applicable to his own case, the old proverbial riddle of Hesiod, *πλεον ἡμισυ παντος, the half is more than the whole.* What did he mean by that? We understand it thus: that between the selling and buying, the variations had been such as to sink his shares to one half of the price they had once reached, but, even at that depreciation, to leave him richer on selling out than he had been at first. But the half of L.25,000 would be a far larger sum than Pope could have ventured to risk upon a fund confessedly liable to daily fluctuation. L.3000 would be the utmost he could risk; in which case the half of L.25,000 would have left him so very much richer, that he would have proclaimed his good fortune as an evidence of his skill and prudence. Yet, on the contrary, he wished his friends to understand at times that he had lost. But his friends forgot to ask one important question: was the word *loss* to be understood in relation to the imaginary and nominal wealth which he once possessed, or in relation to the absolute sum invested in the South Sea fund? The truth is, Pope practised on this, as on other occasions, a little finessing, which is the chief foible in his character. His object was, that, according to circumstances, he might vindicate his own freedom from the common mania, in case his enemies should take that handle for attacking him; or might have it in his power to plead poverty, and to account for it, in case he should ever accept that pension which had been so often tendered but never sternly rejected. Pope.

In 1723 Pope lost one of his dearest friends, Bishop Atterbury, by banishment; a sentence most justly incurred, and mercifully mitigated by the hostile Whig government. On the bishop's trial a circumstance occurred to Pope which flagrantly corroborated his own belief in his natural disqualification for public life. He was summoned as an evidence on his friend's behalf. He had but a dozen words to say, simply explaining the general tenor of his lordship's behaviour at Bromley, and yet, under this trivial task, though supported by the enthusiasm of his friendship, he broke down. Lord Bolingbroke, returning from exile, met the bishop at the sea-side; upon which it was wittily remarked that they were "exchanged." Lord Bolingbroke supplied to Pope the place, or perhaps more than supplied the place, of the friend he had lost; for Bolingbroke was a free-thinker, and so far more entertaining to Pope, even whilst partially dissenting, than Atterbury, whose clerical profession laid him under restraints of decorum, and latterly, there is reason to think, of conscience.

In 1725, on closing the Odyssey, Pope announces his intention to Swift of quitting the labours of a translator, and thenceforwards applying himself to original composition. This resolution led to the Essay on Man, which appeared soon afterwards; and, with the exception of two labours, which occupied Pope in the interval between 1726 and 1729, the rest of his life may properly be described as dedicated to the further extension of that Essay. The two works which he interposed were a collection of the fugitive papers, whether prose or verse, which he and Dean Swift had scattered amongst their friends at different periods of life. The avowed motive for this publication, and, in fact, the secret motive, as disclosed in Pope's confidential letters, was to make it impossible thenceforwards for piratical publishers like Curll. Both Pope and Swift dreaded the malice of Curll in case they should die before him. It was one of Curll's regular artifices to publish a heap of trash on the death of any eminent man, under the title of his Remains; and in allusion to that practice it was that Arbuthnot most wittily called Curll "one of the new terrors of death." By publishing *all*, Pope would have disarmed Curll beforehand; and *that* was in fact the purpose; and that plea only could be offered by two grave authors, one forty, the other sixty years old, for reprinting *jeux d'esprit* that never had any other apology than the youth of their authors. Yet, strange to say, after all, some were omitted; and the omission of one opened the door to Curll as well as that of a score. Let Curll have once inserted the narrow end of the wedge, he would soon have driven it home.

This Miscellany, however, in three volumes (published in 1727, but afterwards increased by a fourth in 1732), though in itself a trifling work, had one vast consequence. It drew after it swarms of libels and lampoons, levelled almost exclusively at Pope, although the cipher of the joint authors stood entwined upon the title-page. These libels in *their* turn produced a second re-action; and, by stimulating Pope to effectual anger, eventually drew forth, for the everlasting admiration of posterity, the very greatest of Pope's works; a monument of satirical power the greatest which man has produced, not excepting the MacFleckno of Dryden, namely, the immortal Dunciad.

In October of the year 1727, this poem, in its original form, was completed. Many editions, not spurious altogether, nor surreptitious, but with some connivance, not yet explained, from Pope, were printed in Dublin and in London. But the first quarto and acknowledged edition was published in London early in "1728–9," as the editors choose to write it, that is (without perplexing the reader), in 1729: on March 12 of which year it was presented by the prime minister, Sir Robert Walpole, to the king and queen at St James's.

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Pope. Like a hornet, who is said to leave his sting in the wound, and afterwards to languish away, Pope felt so greatly exhausted by the efforts connected with the Dunciad (which are far greater, in fact, than all his Homeric labours put together), that he prepared his friends to expect for the future only an indolent companion and a hermit. Events rapidly succeeded which tended to strengthen the impression he had conceived of his own decay, and certainly to increase his disgust with the world. In 1732 died his friend Atterbury; and on December the 7th of the same year Gay, the most unpretending of all the wits whom he knew, and the one with whom he had at one time been domesticated, expired, after an illness of three days, which Dr Arbuthnot declares to have been "the most precipitate" he ever knew. But in fact Gay had long been decaying, from the ignoble vice of too much and too luxurious eating. Six months after this loss, which greatly affected Pope, came the last deadly wound which this life could inflict, in the death of his mother. She had for some time been in her dotage, and recognised no face but that of her son, so that her death was not unexpected; but that circumstance did not soften the blow of separation to Pope. She died on the 7th of June 1733, being then ninety-three years old. Three days after, writing to Richardson the painter for the purpose of urging him to come down and take her portrait before the coffin was closed, he says, "I thank God, her death was as easy as her life was innocent; and as it cost her not a groan, nor even a sigh, there is yet upon her countenance such an expression of tranquillity" that "it would afford the finest image of a saint expired that ever painting drew. Adieu, may you die as happily." The funeral took place on the 11th; Pope then quitted the house, unable to support the silence of her chamber, and did not return for months, nor in fact ever reconciled himself to the sight of her vacant apartment.

Swift also he had virtually lost for ever. In April 1727 this unhappy man had visited Pope for the last time. During this visit occurred the death of George I. Great expectations arose from that event amongst the Tories, in which, of course, Swift shared. It was reckoned upon as a thing of course that Walpole would be dismissed. But this bright gleam of hope proved as treacherous as all before; and the anguish of this final disappointment perhaps it was which brought on a violent attack of Swift's constitutional malady. On the last of August he quitted Pope's house abruptly; concealed himself in London; and finally quitted it, as stealthily as he had before quitted Twickenham, for Ireland, never more to return. He left a most affectionate letter for Pope; but his affliction, and his gloomy anticipations of insanity, were too oppressive to allow of his seeking a personal interview.

Pope might now describe himself pretty nearly as *ultimus suorum;* and if he would have friends in future, he must seek them, as he complains bitterly, almost amongst strangers and another generation. This sense of desolation may account for the acrimony which too much disfigures his writings henceforward. Between 1732 and 1740, he was chiefly engaged in satires, which uniformly speak a high moral tone in the midst of personal invective; or in poems directly philosophical, which almost as uniformly speak the bitter tone of satire in the midst of dispassionate ethics. His Essay on Man was but one link in a general course which he had projected of moral philosophy, here and there pursuing his themes into the fields of metaphysics, but no farther in either field of morals or metaphysics than he could make compatible with a poetical treatment. These works, however, naturally entangled him in feuds of various complexions with people of very various pretensions; and to admirers of Pope so fervent as we profess ourselves, it is painful to acknowledge that the dignity of his latter years, and the becoming tranquillity of increasing age, are sadly disturbed by the petulance and the tone of irritation which, alike to those in the wrong and in the right, inevitably besiege all personal disputes. He was agitated, besides, by a piratical publication of his correspondence. This emanated of course from the den of Curll, the universal robber and "*blatant beast*" of those days; and, besides the injury offered to his feelings by exposing some youthful sallies which he wished to have suppressed, it drew upon him a far more disgraceful imputation, most assuredly unfounded, but accredited by Dr Johnson, and consequently in full currency to this day, of having acted collusively with Curll, or at least through Curll, for the publication of what he wished the world to see, but could not else have devised any decent pretext for exhibiting. The disturbance of his mind on this occasion led to a circular request, dispersed amongst his friends, that they would return his letters. All complied except Swift. He only delayed, and in fact shuffled. But it is easy to read in his evasions, and Pope, in spite of his vexation, read the same tale, viz. that, in consequence of his recurring attacks and increasing misery, he was himself the victim of artifices amongst those who surrounded him. What Pope apprehended happened. The letters were all published in Dublin and in London, the originals being then only returned when they had done their work of exposure. Pope.

Such a tenor of life, so constantly fretted by petty wrongs, or by leaden insults, to which only the celebrity of their object lent force or wings, allowed little opportunity to Pope for recalling his powers from angry themes, and converging them upon others of more catholic philosophy. To the last he continued to conceal vipers beneath his flowers; or rather, speaking proportionately to the case, he continued to sheath amongst the gleaming but innocuous lightnings of his departing splendours, the thunderbolts which blasted for ever. His last appearance was his greatest. In 1742 he published the fourth book of the Dunciad; to which it has with much reason been objected, that it stands in no obvious relation to the other three, but which, taken as a separate whole, is by far the most brilliant and the weightiest of his works. Pope was aware of the *hiatus* between this last book and the rest, on which account he sometimes called it the greater Dunciad; and it would have been easy for him, with a shallow Warburtonian ingenuity, to invent links that might have satisfied a mere *verbal* sense of connection. But he disdained this puerile expedient. The fact was, and could not be disguised from any penetrating eye, that the poem was not a pursuit of the former subjects; it had arisen spontaneously at various times, by looking at the same general theme of dulness (which, in Pope's sense, includes all aberrations of the intellect, nay, even any defective equilibrium amongst the faculties) under a different angle of observation, and from a different centre. In this closing book, not only bad authors, as in the other three, but all abuses of science or antiquarian knowledge, or connoisseurship in the arts, are attacked: virtuosi, medalists, butterfly-hunters, florists, erring metaphysicians, &c. are all pierced through and through as with the shafts of Apollo. But the imperfect plan of the work as to its internal economy, no less than its exterior relations, is evident in many places; and in particular the whole catastrophe of the poem, if it can be so called, is linked to the rest by a most insufficient incident. To give a closing grandeur to his work, Pope had conceived the idea of representing the earth as lying universally under the incubation of one mighty spirit of dulness; a sort of millennium, as we may call it, for ignorance, error, and stupidity. This would take leave of the reader with effect; but how was it to be introduced? at what era? under what exciting cause? As to the eras, Pope could not settle that; unless it were a *future* era, the description of it could not be delivered as a prophecy; and, not being prophetic, it would want much of its grandeur.

Pope. Yet, *as* a part of futurity, how is it connected with our present times? Do they and their pursuits lead to it as a possibility, or as a contingency upon certain habits which we have it in our power to eradicate (in which case this vision of dulness has a *practical* warning), or is it a mere necessity, one amongst the many changes attached to the cycles of human destiny, or which chance brings round with the revolutions of its wheel? All this Pope could not determine; but the exciting cause he *has* determined, and it is preposterously below the effect. The goddess of dulness yawns; and her yawn, which, after all, should rather express the fact and state of universal dulness than its cause, produces a change over all nations tantamount to a long eclipse. Meantime, with all its defects of plan, the poem, as to execution, is superior to all which Pope has done; the composition is much superior to that of the Essay on Man, and more profoundly poetic: the parodies drawn from Milton, as also in the former books, have a beauty and effect which cannot be expressed; and, if a young lady wished to cull for her album a passage from all Pope's writings, which, without a trace of irritation or acrimony, should yet present an exquisite gem of independent beauty, she could not find another passage equal to the little story of the florist and the butterfly-hunter. They plead their cause separately before the throne of dulness; the florist telling how he had reared a superb carnation, which, in honour of the queen, he called Caroline, when his enemy, pursuing a butterfly which settled on the carnation, in securing his own object, had destroyed that of the plaintiff. The defendant replies with equal beauty; and it may certainly be affirmed, that, for brilliancy of colouring and the art of poetical narration, the tale is not surpassed by any in the language.

This was the last effort of Pope worthy of separate notice. He was now decaying rapidly, and sensible of his own decay. His complaint was a dropsy of the chest, and he knew it to be incurable. Under these circumstances, his behaviour was admirably philosophical. He employed himself in revising and burnishing all his later works, as those upon which he wisely relied for his reputation with future generations. In this task he was assisted by Dr Warburton, a new literary friend, who had introduced himself to the favourable notice of Pope about four years before, by a defence of the Essay on Man, which Crousaz had attacked, but in general indirectly and ineffectually, by attacking it through the blunders of a very faulty translation. This poem, however, still labours, to religious readers, under two capital defects. If man, according to Pope, is now so admirably placed in the universal system of things, that evil only could result from any change, then it seems to follow, either that a fall of man is inadmissible; or at least, that, by placing him in his true centre, it had been a blessing universally. The other objection lies in this, that if all is right already, and in this earthly station, then one argument for a future state, as the scene in which evil is to be redressed, seems weakened or undermined.

As the weakness of Pope increased, his nearest friends, Lord Bolingbroke, and a few others, gathered around him. The last scenes were passed almost with ease and tranquillity. He dined in company two days before he died; and on the very day preceding his death he took an airing on Blackheath. A few mornings before he died, he was found very early in his library writing on the immortality of the soul. This was an effort of delirium; and he suffered otherwise from this affection of the brain, and from inability to think in his closing hours. But his humanity and goodness, it was remarked, had survived his intellectual faculties. He died on the 30th of May 1744; and so quietly, that the attendants could not distinguish the exact moment of his dissolution. Pope.

We had prepared an account of Pope's quarrels, in which we had shown that, generally, he was not the aggressor; and often was atrociously ill used before he retorted. This service to Pope's memory we had judged important, because it is upon these quarrels chiefly that the erroneous opinion has built itself of Pope's fretfulness and irritability. And this unamiable feature of his nature, together with a proneness to petty manœuvring, are the main foibles that malice has been able to charge upon Pope's moral character. Yet, with no better foundation for their malignity than these doubtful propensities, of which the first perhaps was a constitutional defect, a defect of his temperament rather than his will, and the second has been much exaggerated, many writers have taken upon themselves to treat Pope as a man, if not absolutely unprincipled and without moral sensibility, yet as mean, little-minded, indirect, splenetic, vindictive, and morose. Now the difference between ourselves and these writers is fundamental. They fancy that in Pope's character a basis of ignoble qualities was here and there slightly relieved by a few shining spots; we, on the contrary, believe that in Pope lay a disposition radically noble and generous, clouded and overshadowed by superficial foibles, or, to adopt the distinction of Shakspeare, they see nothing but "dust a little gilt," and we "gold a little dusted." A very rapid glance we will throw over the general outline of his character.

As a friend, it is noticed emphatically by Martha Blount and other contemporaries, who must have had the best means of judging, that no man was so warm hearted, or so much sacrificed himself for others, as Pope; and in fact many of his quarrels grew out of this trait in his character. For once that he levelled his spear in his own quarrel, at least twice he did so on behalf of his insulted parents or his friends. Pope was also noticeable for the duration of his friendships;[1] some dropped him, but he never any throughout his life. And let it be remembered, that amongst Pope's friends were the men of most eminent talents in those days; so that envy at least, or jealousy of rival power, was assuredly no foible of his. In that respect how different from Addison, whose petty manœuvring against Pope proceeded entirely from malignant jealousy. That Addison was more in the wrong even than has generally been supposed, and Pope more thoroughly innocent as well as more generous, we have the means at a proper opportunity of showing decisively. As a son, we need not insist on Pope's pre-eminent goodness. Dean Swift, who had lived for months together at Twickenham, declares that he had not only never witnessed, but had never heard of anything like it. As a Christian, Pope appears in a truly estimable light. He found himself a Roman Catholic by accident of birth; so was his mother; but his father was so upon personal conviction and conversion, yet not without extensive study of the questions at issue. It would have laid open the road to preferment, and preferment was otherwise abundantly before him, if Pope would have gone over to the Protestant faith. And in his conscience he found no obstacle to that change; he was a philosophical Christian, intolerant of nothing but into-

[1] We may illustrate this feature in the behaviour of Pope to Savage. When all else forsook him, when all beside pleaded the insults of Savage for withdrawing their subscriptions, Pope sent his in advance. And when Savage had insulted *him* also, arrogantly commanding him never "to presume to interfere or meddle in his affairs," dignity and self-respect made Pope obedient to these orders, except when there was an occasion of serving Savage. On his second visit to Bristol (when he returned from Glamorganshire), Savage had been thrown into the jail of the city. One person only interested himself for this hopeless profligate, and was causing an inquiry to be made about his debts at the time Savage died. So much Dr Johnson admits; but he *forgets* to mention the name of this long-suffering friend. *It was Pope.* Meantime, let us not be supposed to believe the lying legend of Savage; he was doubtless no son of Lady Macclesfield's, but an impostor, who would now be sent to the tread-mill.

Pope.

lerance, a bigot only against bigots. But he remained true to his baptismal profession, partly on a general principle of honour in adhering to a distressed and dishonoured party, but chiefly out of reverence and affection to his mother. In his relation to women, Pope was amiable and gentlemanly; and accordingly was the object of affectionate regard and admiration to many of the most accomplished in that sex. This we mention especially because we would wish to express our full assent to the manly scorn with which Mr Roscoe repels the libellous insinuations against Pope and Miss Martha Blount. A more innocent connection we do not believe ever existed. As an author, Warburton has recorded that no man ever displayed more candour or more docility to criticisms offered in a friendly spirit. Finally, we sum up all in saying, that Pope retained to the last a true and diffusive benignity; that this was the quality which survived all others, notwithstanding the bitter trial which his benignity must have stood through life, and the excitement to a spiteful re-action of feeling which was continually pressed upon him by the scorn and insult which his deformity drew upon him from the unworthy.

But the moral character of Pope is of secondary interest: we are concerned with it only as connected with his great intellectual power. There are three errors which seem current upon this subject: *First*, that Pope drew his impulses from French literature; *secondly*, that he was a poet of inferior rank; *thirdly*, that his merit lies in superior "correctness." With respect to the first notion, it has prevailed by turns in every literature. One stage of society, in every nation, brings men of impassioned minds to the contemplation of manners, and of the social affections of man as exhibited in manners. With this propensity co-operates, no doubt, some degree of despondency when looking at the great models of the literature who have usually preoccupied the grander passions, and displayed their movements in the earlier periods of literature. Now it happens that the French, from an extraordinary defect in the higher qualities of passion, have attracted the notice of foreign nations chiefly to that field of their literature in which the taste and the unimpassioned understanding preside. But in all nations such literature is a natural growth of the mind, and would arise equally if the French literature had never existed. The wits of Queen Anne's reign, or even of Charles II.'s, were not French by their taste or their imitation. Butler and Dryden were surely not French; and of Milton we need not speak; as little was Pope French, either by his institution or by his models. Boileau he certainly admired too much; and, for the sake of a poor parallelism with a passage about Greece in Horace, he has falsified history in the most ludicrous manner, without a shadow of countenance from facts, in order to make out that we, like the Romans, received laws of taste from those whom we had conquered. But these are insulated cases and accidents, not to insist on his known and most profound admiration, often expressed, for both Chaucer, and Shakspeare, and Milton. Secondly, that Pope is to be classed as an inferior poet, has arisen purely from a confusion between the departments of poetry which he cultivated and the merit of his culture. The first place must undoubtedly be given for ever,—it cannot be refused,—to the impassioned movements of the tragic, and to the majestic movements of the epic muse. We cannot alter the relations of things out of favour to an individual. But in his own department, whether higher or lower, that man is supreme who has not yet been surpassed; and such a man is Pope. As to the final notion, first started by Walsh, and propagated by Warton, it is the most absurd of all the three; it is not from superior correctness that Pope is esteemed more correct, but because the compass and sweep of his performances lies more within the range of ordinary judgments. Many questions that have been raised upon Milton or Shakspeare, questions relating to so subtile a subject as the flux and reflux of human passion, lie far above the region of ordinary capacities; and the indeterminateness or even carelessness of the judgment is transferred by a common confusion to its objects. But waiving this, let us ask, what is meant by "correctness?" Correctness in what? In developing the thought? In connecting it, or effecting the transitions? In the use of words? In the grammar? In the metre? Under every one of these limitations of the idea, we maintain that Pope is *not* distinguished by correctness; nay, that, as compared with Shakspeare, he is eminently incorrect. Produce us from any drama of Shakspeare one of those leading passages that all men have by heart, and show us any eminent defect in the very sinews of the thought. It is impossible; defects there may be, but they will always be found irrelevant to the main central thought, or to its expression. Now turn to Pope; the first striking passage which offers itself to our memory, is the famous character of Addison, ending thus:

> Who would not laugh, if such a man there be,
> Who but must weep if Atticus were he?

Why must we laugh? Because we find a grotesque assembly of noble and ignoble qualities. Very well; but why then must we weep? Because this assemblage is found actually existing in an eminent man of genius. Well, that is a good reason for weeping; we weep for the degradation of human nature. But then revolves the question, why must we laugh? Because, if the belonging to a man of genius were a sufficient reason for weeping, so much we know from the very first. The very first line says "Peace to all such. But were there one whose fires *true genius kindles* and fair fame inspires." Thus falls to the ground the whole antithesis of this famous character. We are to change our mood from laughter to tears upon a sudden discovery that the character belonged to a man of genius; and this we had already known from the beginning. Match us this prodigious oversight in Shakspeare. Again, take the Essay on Criticism: it is a collection of independent maxims, tied together into a fasciculus by the printer, but having no natural order or logical dependency; generally so vague as to mean nothing: like the general rules of justice, &c. in ethics, to which every man assents; but when the question comes about any practical case, *is* it just? the opinions fly asunder far as the poles. And, what is remarkable, many of the rules are violated by no man so often as by Pope, and by Pope nowhere so often as in this very poem. As a single instance, he proscribes monosyllabic lines; and in no English poem of any pretensions are there so many lines of that class as in this. We have counted above a score, and the last line of all is monosyllabic.

Not therefore for superior correctness, but for qualities the very same as belong to his most distinguished brethren, is Pope to be considered a great poet; for impassioned thinking, powerful description, pathetic reflection, brilliant narration. His characteristic difference is simply that he carried these powers into a different field, and moved chiefly amongst the social paths of men, and viewed their characters as operating through their manners. And our obligations to him arise chiefly on this ground, that having already, in the persons of earlier poets, carried off the palm in all the grander trials of intellectual strength, for the majesty of the epopee and the impassioned vehemence of the tragic drama, to Pope we owe it that we can now claim an equal preeminence in the sportive and aërial graces of the mock heroic and satiric muse; that in the Dunciad we possess a peculiar form of satire, in which (according to a plan unattempted by any other nation) we see alternately her festive smile and her gloomiest scowl; that the grave good sense of the nation has here found its brightest mirror; and, finally, that through Pope the cycle of our poetry is perfected and made orbicular, that from that day we might claim the laurel equally, whether for dignity or grace. (W. W. W.)

Pope.

Poperinghen | Popery.

POPERINGHEN, a large market-town of Belgium, in the province of West Flanders and circle of Ypres. It stands on the river Schipuor, and contains two churches, 1400 houses, and 9080 inhabitants, who are employed in making linen and woollen cloths, and thread-lace, and have several oil mills. It is celebrated for the growth of hops on the land around it, which is a valuable part of its trade.

POPERY, in *Ecclesiastical History*, is regarded by Roman Catholics as a term of reproach, but having been generally received amongst Protestants, now comprehends the religious doctrines and practices adopted and maintained by the church of Rome. The following summary, extracted chiefly from the decrees of the council of Trent, continued under Paul III., Julius III., and Pius IV., by successive sessions, from the year 1545 to 1563, and the creed of Pope Pius IV. subjoined to it, and bearing date November 1564, may not be unacceptable to the reader. One of the fundamental tenets strenuously maintained by Catholic writers, is the infallibility of the church of Rome; and though they are not agreed whether this privilege belongs to the pope or a general council, or to both united, yet they pretend that an infallible living judge is absolutely necessary to determine controversies, and to secure peace, in the Christian church. Protestants, however, allege that the claim of infallibility in any church is not justified by the authority of Scripture, much less does it appertain to the church of Rome; that it is inconsistent with the nature of religion, and the personal obligations of its professors; and that it has proved ineffectual to the end for which it is supposed to have been granted, since popes and councils have disagreed in matters of importance, and, with the advantage of this pretended infallibility, have been incapable of maintaining union and peace. Another essential article of the Catholic creed is the supremacy of the pope, or his sovereign power over the universal church.

Further, the doctrine of the seven sacraments is a peculiar and distinguishing doctrine of the church of Rome. These are baptism, confirmation, the eucharist, penance, extreme unction, holy orders, and matrimony. The council of Trent (sess. vii. can. 1) pronounces an anathema upon those who say that the sacraments are more or fewer than seven, or that any one of the above number is not truly and properly a sacrament. And yet it does not appear that they amounted to this number before the twelfth century, when Hugo de St Victoire and Peter Lombard, about the year 1144, taught that there were seven sacraments. The council of Florence, held in the year 1438, was the first council which determined this number. These sacraments confer grace, according to the decree of the council of Trent (sess. vii. can. 8) *ex opere operato*, that is, by the mere administration of them; three of them, viz. baptism, confirmation, and holy orders, are said (can. 9) to impress an indelible character, so that they cannot be repeated without sacrilege; and the efficacy of every sacrament depends upon the intention of the priest by whom it is administered (can. 11). Pope Pius expressly enjoins that all these sacraments should be administered according to the received and approved rites of the Catholic church. With regard to the eucharist in particular, we may here observe, that the church of Rome holds the doctrine of transubstantiation; the necessity of paying divine worship to Christ under the form of the consecrated bread, or host; and the propitiatory sacrifice of the mass, according to the Catholic ideas of which Christ is truly and properly offered as a sacrifice of propitiation as often as the priest says mass. It likewise practises solitary mass, in which the priest alone consecrates, communicates, and allows communion only in one kind, namely, the bread, to the laity. (Sess. 14.)

The doctrine of merits is another distinguishing tenet of Popery, with regard to which the council of Trent has expressly decreed (sess. vi. can. 32) that the good works of justified persons are truly meritorious, deserving not only an increase of grace, but eternal life, and an increase of glory; and it has anathematized all who deny this doctrine. Of the same kind is the doctrine of satisfaction, which supposes that penitents may truly satisfy, by the afflictions they endure under the dispensations of Providence, or by voluntary penances to which they submit, for the temporary penalties of sin, to which they are subject even after the remission of their eternal punishment. (Sess. vi. can. 30; and sess. xiv. can. 8 and 9.) In this connection we may mention the distinction of venial and mortal sins. The greatest evils arising from the former are the temporary pains of purgatory; but no man, it is said, can obtain the pardon of the latter without confessing to a priest, and performing the penances which he imposes. Popery.

The council of Trent (sess. xiv. can. 1) has expressly decreed, that every one is accursed who shall affirm that penance is not truly and properly a sacrament, instituted by Christ in the universal church, for reconciling those Christians to the divine majesty, who have fallen into sin after baptism. And this sacrament, it is declared, consists of two parts, the matter and the form; the matter being the act of the penitent, including contrition, confession, and satisfaction; the form, the act of absolution on the part of the priest. Accordingly it is enjoined, that it is the duty of every man who has fallen after baptism, to confess his sins, once a year at least, to a priest; that this confession is to be secret, for public confession is neither commanded nor expedient; and that it must be exact and particular, including every kind and act of sin, with all the circumstances attending it. When the penitent has so done, the priest pronounces an absolution, which is not conditional or declarative only, but absolute and judicial. This secret or auricular confession was first decreed and established in the fourth council of Lateran, under Pope Innocent III. in 1215 (cap. 21); and the decree of this council was afterwards confirmed and enlarged in the council of Florence and in that of Trent, which ordains, that confession was instituted by Christ, that by the law of God it is necessary to salvation, and that it has always been practised in the Christian church. As for the penances imposed on the penitent by way of satisfaction, they have been commonly the repetition of certain forms of devotion, as paternosters or ave-marias, the payment of stipulated sums, pilgrimages, fasts, or various species of corporal discipline. But the most formidable penance, in the estimation of those who belong to the communion of the church of Rome, is the temporary pains of purgatory. Yet under all the penalties which are inflicted or threatened in that church, it has provided relief by its indulgences, and by its prayers or masses for the dead, performed professedly for relieving and rescuing the souls that are detained in purgatory.

Another article which has long been authoritatively enjoined and observed in the church of Rome, is the celibacy of her clergy. This was first enjoined at Rome by Gregory VII. about the year 1074, and established in England by Anselm archbishop of Canterbury about the year 1175; though his predecessor Lanfranc had imposed it upon the prebendaries and clergy who lived in towns. And though the council of Trent was repeatedly petitioned by several princes and states to abolish this restraint, yet the obligation of celibacy was rather established than relaxed by this council; for they decreed, that marriage contracted after a vow of continence is neither lawful nor valid, and thus deprived the church of the possibility of ever restoring marriage to the clergy. If marriage, after a vow, be in itself unlawful, the greatest authority upon earth cannot dispense with it, nor permit marriage to the clergy, who have already vowed continence.

To the doctrines and practices above recited may further be added the worship of images, of which Protestants ac-

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cuse the Papists. But to this accusation the Papist replies, that he keeps images by him to preserve in his mind the memory of the persons represented by them, as people are wont to preserve the memory of their deceased friends by keeping their pictures. He is taught, he says, to use them so as to cast his eyes upon the pictures or images, and thence to raise his heart to the things represented, and there to employ it in meditation, love, thanksgiving, and desire of imitation, as the object requires. These pictures or images have this advantage, that they inform the mind by one glance, of what in reading might require a whole chapter; there being no other difference between them, than that reading represents leisurely and by degrees, whilst a picture does so at once. Hence he finds a convenience in saying his prayers with some devout pictures before him, the sight of which recalls his wandering thoughts to the right object, and as certainly brings something good into his mind, as an immodest picture disturbs his heart with unclean thoughts. And because he is sensible that these holy pictures and images represent and bring to his mind such objects as in his heart he loves, honours, and venerates, he cannot but on that account love, honour, and respect, the images themselves.[1]

The council of Trent likewise decreed, that all bishops and pastors who have the cure of souls, do diligently instruct their flocks that it is good and profitable to desire the intercession of saints reigning with Christ in heaven. And this decree the Papists endeavour to defend by many arguments. They confess that we have but one Mediator of redemption, but affirm that it is acceptable to God that we should have many mediators of intercession. Moses, say they, was such a mediator for the Israelites; Job for his three friends; Stephen for his persecutors. The Romans were thus desired by St Paul to be his mediators; so were the Corinthians and the Ephesians, so almost every sick man desires the congregation to be his mediators, by remembering him in their prayers. And so, too, the Papist desires the blessed in heaven to be his mediators, that is, that they would pray to God for him. But between these living and dead mediators there is no similarity. The living mediator is present, and certainly hears the request of those who desire him to intercede for them; the dead mediator is as certainly absent, and cannot possibly hear the requests of all those who at the same instant may be begging him to intercede for them, unless he be possessed of the divine attribute of omnipresence; and he who ascribes that attribute to any creature is unquestionably guilty of idolatry. Besides, as this decree is contrary to one of the first principles of natural religion, so it receives no countenance from Scripture, or any Christian writer of the first three centuries. Other practices peculiar to the Papists are the religious honour and respect that they pay to sacred relics, by which they understand not only the bodies and parts of the bodies of the saints, but any of those things that appertained to them, and which they had touched; and the celebration of divine service in an unknown tongue, in regard to which the council of Trent has denounced an anathema on any one who shall say that mass ought to be celebrated only in the vulgar tongue (session xxv. and session xxii. can. 9). Though the council of Lateran under Innocent III. in 1215, had (can. 9) expressly decreed, that as in several parts within the same city and diocese there are many people of different manners and rites mixed together, but of one faith, so the bishops of such cities or dioceses should provide fit men for celebrating divine offices, according to the diversity of tongues and rites, and for administering the sacraments.

We shall only add further, that the church of Rome maintains that unwritten traditions ought to be added to the holy Scriptures, in order to supply their defect, and should be regarded as of equal authority; that the books of the Apocrypha are canonical Scripture; that the vulgate edition of the Bible is to be deemed authentic; and that the Scriptures are to be received and interpreted according to that sense which the holy mother church, to whom it belongs to judge of the true sense, has held, and does hold, and according to the unanimous consent of the Fathers.

Popham Poplar.

Such are the principal and distinguishing doctrines of Catholicism or Popery, most of which have received the sanction of the council of Trent, and that of the creed of Pope Pius IV. which is received, professed, and sworn to by every one who enters into holy orders in the church of Rome, as well as by all proselytes or converts: And at the close of this creed, we are told that the faith contained in it is so absolutely and indispensably necessary, that no man can be saved without it.

POPHAM, Sir John, lord chief justice of the common pleas in the reign of Queen Elizabeth, was the eldest son of Mr Edward Popham of Huntworth, in Somersetshire, and born in the year 1531. He was some time a student of Baliol College, Oxford; "being then," as Anthony Wood says, "given at leisure hours to many sports and exercises." After quitting the university, he established himself in the Middle Temple, where, during his novitiate, he is said to have indulged in that kind of dissipation to which youth and a vigorous constitution more naturally incline, than to the study of voluminous reports; but, satiated at length with what are called the pleasures of the town, he applied sedulously to the study of his profession, was called to the bar, and in 1568 became summer or autumn reader. He was soon afterwards made serjeant at law, and solicitor-general in 1579. In 1581 he was appointed attorney-general, and treasurer of the Middle Temple. In 1592 he was made lord chief justice of the king's bench, and the same year received the honour of knighthood. In the year 1601 his lordship was one of the council detained by the unfortunate Earl of Essex, when he formed the ridiculous project of defending himself in his own house; and, on the earl's trial, Sir John gave evidence against him relative to their detention. He died in the year 1607, aged seventy-six, and was buried in the south aisle of the church at Wellington in Somersetshire, where he generally resided as often as it was in his power to retire. He was thought somewhat severe in the execution of the law against capital offenders; but his severity had the happy effect of reducing the number of highway robberies. He wrote, 1. Reports and cases adjudged in the time of Queen Elizabeth; 2. Resolutions and judgments upon cases and matters agitated in all the courts at Westminster in the latter end of Queen Elizabeth's reign.

POPILIUS, Lænas, Roman ambassador to Antiochus, king of Syria. He was commissioned to order that monarch to desist from hostilities against Ptolemy, king of Egypt, ally of Rome. Antiochus attempted to elude him by evasive answers; but Popilius, with a stick in his hand, made a circle round him in the sand, and charged him, in the name of the Roman senate and people, not to go beyond it till he gave a decisive answer. This boldness intimidated Antiochus, who immediately withdrew his garrisons from Egypt, and desisted from his hostile attempts against Ptolemy.

POPLAR, a parish of the county of Middlesex, in the hundred of Ossulton. It stands on the banks of the river Thames, and was formerly a hamlet in the parish of Stepney. It is extensive, and comprehends the Isle of Dogs, which was formerly a rich marsh, but is now in part converted into docks and canals. The construction of the West India Docks has of late years tended very much to increase the population, which consists chiefly of persons directly or in-

[1] See Gother's Papist Misrepresented and Represented.

Popo ‖ Population.

directly connected with shipping. In that part of the parish known by the name of Blackwall is the largest private establishment for ship-building in the kingdom. In it there are also many manufactories for rope-making, anchor-forging, and preparing the several other component parts of vessels. There is also a commodious hospital for persons who have been in the service of the East India Company. The population amounted in 1801 to 4493, in 1811 to 7708, in 1821 to 12,223, and in 1831 to 16,849.

POPO is the name of one of the states comprised in what is denominated the Slave Coast, on the western shores of Africa. In the strictest acceptation, the Slave Coast includes the states of Coto, Popo, Widah, and Ardra, the whole being subject to the king of Dahomey. The maritime flat country here is broader than that of the Gold Coast, and very fertile. The inhabitants are warlike, and addicted to cheating and thieving. This state is divided into the Great and Little Popo. The capital of the former stands on an island at the mouth of a river, which is rendered useless for the navigation of vessels, on account of a formidable bar at its mouth. The capital of Little Popo is situated on the shore near a small river or inlet of the sea. Poultry are here in uncommon abundance; and the flocks of bats are so numerous that they darken the air like dense clouds.

Popo Isle ‖ Population.

Popo *Isle*, an island or cluster of islands in the Eastern Seas, the chief of which is about fifty miles in circumference. They are distant five leagues from the islands of Bo, and exceed them in height. They are inhabited, and afford a supply of nuts and dried fish. Long. 130. 0. 15. E. Lat. 19. 14. S.

POPOCA, Mount, one of the volcanoes on the summits of the American Cordilleras. Its crater is said to be half a league in circumference.

POPPÆA, Sabina, a Roman matron, daughter of Titus Ollius. She was married and had a son to Rufus Crispinus, a Roman knight. Her beauty captivated Otho, one of Nero's favourites, who carried her off and married her; but he was not long permitted to retain her, for Nero, having heard her extolled for her accomplishments, sent Otho out of Italy, under pretence of presiding over one of the Roman provinces, shortly after which Nero repudiated his wife Octavia, and married Poppæa; but she did not long enjoy the imperial dignity, for Nero soon began to despise her, and treat her with great barbarity. She bore him a son; and when she was again far advanced in pregnancy, he struck her a blow with his foot, of which she died, about 65 A. D. It is said she was so anxious to preserve her beauty, that five hundred she-asses were kept to afford milk, in which she used daily to bathe.

POPULATION.

Object of the article.

The population of the principal states, of which an account has been given in the course of this work, will be found under their proper heads. The object of this article is to explain the general laws which regulate the increase or decrease of population, and the manner in which they affect the state and condition of human society.

Tendency of all plants and animals to increase in a geometrical progression.

In taking a view of animated nature, we cannot fail to be struck with a prodigious power of increase in plants and animals. Their capacity in this respect is indeed almost infinitely various, according with the endless variety of the works of nature, and the different purposes which they seem appointed to fulfil. But, whether they increase slowly or rapidly, if they increase by seed or generation, their natural tendency must be to increase in a geometrical ratio, that is, by multiplication; and at whatever rate they are increasing during any one period, if no further obstacles be opposed to them, they must proceed in a geometrical progression.

In the growth of wheat, a vast quantity of seed is unavoidably lost. When it is dibbled instead of being sown in the common way, two pecks of seed wheat will yield as large a crop as two bushels, and thus quadruple the proportion of the return to the quantity of seed put into the ground. In the Philosophical Transactions for 1768, an account is given of an experiment, in which, by separating the roots obtained from a single grain of wheat, and transplanting them in a favourable soil, a return was obtained of above 500,000 grains. But, without referring to peculiar instances or peculiar modes of cultivation, it is known that calculations have often been made, founded on positive experience, of the produce of wheat in different soils and countries, cultivated in an ordinary way, and making allowance for all ordinary destruction of seed.

Humboldt has collected some estimates of this kind, from which it appears that France, the north of Germany, Poland, and Sweden, taken generally, produce from five to six grains for one; some fertile lands in France produce fifteen for one; and the good lands in Picardy and the Isle of France from eight to ten grains for one. Hungary, Croatia, and Sclavonia, yield from eight to ten grains for one. In the Regno de la Plata, twelve grains for one are produced; near the city of Buenos Ayres, sixteen for one; in the northern part of Mexico seventeen; and in the equinoctial regions of Mexico twenty-four for one.[1]

Now, supposing that in any one country during a certain period, and under the ordinary cultivation, the return of wheat was six grains for one, it would be strictly correct to say that wheat had the capacity of increasing in a geometrical ratio, of such a nature as to sextuple itself every year. And it might safely be calculated hypothetically, that if, setting out from the produce of one acre, land of the same quality could be prepared with sufficient rapidity, and no wheat were consumed, the rate of increase would be such as completely to cover the whole earthy surface of our globe in fourteen years.

In the same manner, if it be found by experience that on land of a certain quality, and making allowance for the ordinary mortality and accidents, sheep will increase on an average so as to double their numbers every two years, it would be strictly correct to say, that sheep have the natural capacity of increasing in a geometrical progression, of which the common multiple is two, and the term two years; and it might safely be said, that if land of the same quality could be provided with sufficient rapidity, and no sheep were consumed, the rate of increase would be such, that if we were to begin with the full number which could be supported on an acre of land, the whole earthy part of the globe might be completely covered with sheep in less than seventy-six years.

If out of this prodigious increase of food, the full support of mankind were deducted, supposing them to increase as fast as they have ever yet increased in any country, the deduction would be comparatively inconsiderable; and the rate of increase would still be enormous, till it was checked, either by the natural want of will on the part of mankind to make efforts for the increase of food beyond what they could possibly consume, or, after a certain period, by their absolute want of power to prepare land of the same quality, so as to allow of the same rate of progress.

Owing to these two causes combined, we see that, not-

[1] *Nouvelle Espagne*, liv. iv. c. ix. p. 98.

Population.

withstanding this prodigious power of increase in vegetables and animals, their actual increase is extremely slow; and it is obvious, that, owing to the latter cause alone, and long before a final stop was put to all further progress, their actual rate of increase must of necessity be very greatly retarded; as it would be impossible for the most enlightened human efforts to make all the soil of the earth equal in fertility to the average quality of land now in use; while the practicable approaches towards it would require so much time as to occasion, at a very early period, a constant and great check upon what their increase would be if they could exert their natural powers.

Elevated as man is above all other animals by his intellectual faculties, it is not to be supposed that the physical laws to which he is subjected should be essentially different from those which are observed to prevail in other parts of animated nature. He may increase slower than most other animals, but food is equally necessary to his support; and if his natural capacity of increase be greater than can be permanently supplied with food from a limited territory, his increase must be constantly retarded by the difficulty of procuring the means of subsistence.

The power of producing food limited by the quantity and nature of the soil.

The main peculiarity which distinguishes man from other animals, in the means of his support, is the power which he possesses of very greatly increasing these means. But this power is obviously limited by the scarcity of land, by the great natural barrenness of a very large part of the surface of the earth, and by the decreasing proportion of produce which must necessarily be obtained from the continual additions of labour and capital applied to land already in cultivation.

It is, however, specifically with this diminishing and limited power of increasing the produce of the soil, that we must compare the natural power of mankind to increase, in order to ascertain whether, in the progress to the full cultivation and peopling of the globe, the natural power of mankind to increase must not of absolute necessity be constantly retarded by the difficulty of procuring the means of subsistence, and if so, what are likely to be the effects of such a state of things.

The natural rate of increase applicable to mankind.

In an endeavour to determine the natural power of mankind to increase, as well as their power of increasing the produce of the soil, we can have no other guide than past experience.

The great check to the increase of plants and animals, we know from experience, is the want of room and nourishment; and this experience would direct us to look for the greatest actual increase of them in those situations where room and nourishment were the most abundant.

On the same principle, we should expect to find the greatest actual increase of population in those situations where, from the abundance of good land, and the manner in which its produce is distributed, the largest portion of the necessaries of life is actually awarded to the mass of the society.

Of the countries with which we are acquainted, the United States of America, formerly the North American colonies of Great Britain, answer most nearly to this description. In the United States not only is there an abundance of good land, but, from the manner in which it has been distributed, and the market which has been opened for its produce, there has been a greater and more constant demand for labour, and a larger portion of necessaries has been awarded to the labourer, than in any of those other countries which possess an equal or greater abundance of land and fertility of soil.

Here, then, we should expect to find that the natural power of mankind to increase, whatever it may be, would be most distinctly marked; and here, in consequence, it appears that the actual rate of the increase of population has been more rapid than in any known country, although, independently of the abundance of good land, and the great demand for labour, it is distinguished by no other circumstances which appear to be peculiarly favourable to the increase of numbers.

Population.

It has been stated that all animals, according to the known laws by which they are produced, must have a capacity of increasing in a geometrical progression. And the question with regard to man is, what is the rate of this geometrical progression?

Fortunately, in the country to which we should naturally turn our eyes for an exemplification of the most rapid rate of increase, there have been four enumerations of the people, each at the distance of ten years; and though the estimates of the increase of population in the North American colonies at earlier periods were of sufficient authority, in the absence of more certain documents, to warrant most important inferences, yet as we now possess such documents, and as the period they involve is of sufficient length to establish the point in question, it is no longer necessary to refer to earlier times.

Increase of population in the United States of America.

According to a regular census made by order of Congress in 1790, which there is every reason to think is essentially correct, the white population of the United States was found to be 3,164,148. By a similar census in 1800, it was found to have increased to 4,312,841. It had increased, then, during the ten years from 1790 to 1800, at a rate equal to 36·3 per cent., a rate which, if continued, would double the population in twenty-two years and about four months and a half.

According to a third census, in 1810, the white population was found to be 5,862,092,[1] which, compared with the population of 1800, gives an increase in the second ten years at the rate of nearly thirty-six per cent., which, if continued, would double the population in about twenty-two years and a half.

According to the fourth census, in 1820, the white population was found to be 7,861,710,[2] which, compared with the population of 1810, gives an increase in the third ten years at a rate per cent. of 34·1, which, if continued, would double the population in twenty-three years and seven months.

If we compare the period of doubling according to the rate of increase in the most unfavourable ten years of this series, with twenty-five years, we shall find the difference such as fully to cover all the increase of population which would have taken place from emigration.

Amount of emigration.

It appears from a reference to the most authentic documents which can be collected on both sides of the Atlantic, that the emigration to the United States, during the last twenty-five years, falls decidedly short of an average of 10,000 a year. Dr Seybert, the best authority on the other side of the water, states that, from 1790 to 1810, it could not have been so much as 6000 a year. Our official accounts of the number of emigrants to the United States from England, Ireland, and Scotland, during the ten years from 1812 to 1821 inclusive, give an average of less than 7000, although the period includes the extraordinary years 1817 and 1818, in which the emigrations to the United States were much greater than they were ever known to be before or since. The official American accounts, as far as they go, which is only for two years from the 30th Sep-

[1] These numbers are taken from Dr Seybert's Statistical Annals, p. 23.

[2] This number is taken from the American National Calendar for 1822, and has since been compared with the original census as published for the use of the members of Congress.

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tember 1819, tend to confirm this average;[1] and, allowing fully for the emigrants from other European countries, the general average will still be under the ten thousand.

A new mode was, however, some time ago suggested of estimating the amount of increase in any country derived from emigration.[2] It has been justly stated, that when a census is taken every ten years, and the population is distinguished into those above and those below ten years of age, all above ten years of age, exclusive of emigrants, must have existed in the census immediately preceding, and, consequently, after having made a proper allowance for the mortality during these ten years, the excess above the remaining number must be attributed to emigration. If we had the means of estimating with accuracy the loss which would be sustained in America in ten years by a population not increased by additional births, this mode of estimating the amount of emigration would be unobjectionable, and often very useful.

But unfortunately the means are deficient. Even the annual mortality in the United States is not known. It was supposed by Dr Price (vol. ii. p. 50, 7th edit.) to be one in fifty; by Mr Barton, in the Transactions of the Society at Philadelphia (vol. iii. No. 7), one in forty-five; and it is stated by Mr Bristed, in his work on America and her Resources (p. 20), that the annual deaths average throughout the United States one in forty, in the healthiest districts one in fifty-six, and in the most unhealthy one in thirty-five.

If, however, we could ascertain accurately the average annual mortality, we should still be unable to ascertain the amount of the loss in question; as, under any given law of mortality, it would depend so very much upon the rate at which the population was increasing. The truth of this observation will be placed in a striking light by the following short table, with which we have been favoured by a very able calculator, Mr Milne, author of a well-known Treatise on Annuities and Assurances. It is constructed on the supposition that the population, in each case, is always subject to the same law of mortality as that which prevailed in all Sweden and Finland during the five years ended with 1805, and that the number of births in the present year living in each case is 10,000.

	The Population constantly the same.	The Population increasing in geometrical progression for more than a hundred years, so as to double itself every	
		Fifty Years	Twenty-five Years.
Total population ten years since.....	393,848	230,005	144,358
Total above ten years of age now.....	320,495	195,566	126,176
Died during the term of ten years, out of those living at its commencement.....	73,353	34,439	18,182
Being one of.....	5·3692	6·6786	7·9396

Popula-tion.

We see from this table, that under the same law of mortality, the difference of loss sustained in ten years, by a people not increased by fresh births, would in the three cases supposed, of a stationary population, a population doubling in fifty years, and a population doubling in twenty-five years, be as one in 5·3692, one in 6·6786, and one in 7·9396; and that when the population is doubling itself in twenty-five years, the loss would be very little more than one eighth.

But the censuses must be allowed to form a *prima facie* evidence that the population of the United States has, for a considerable time, been going on doubling itself in twenty-five years; and assuming this evidence to be true, which we are warranted in doing till better evidence is produced on the other side, it will appear that the amount of immigration, deduced from the rule here referred to, is less than 10,000 a year.

Thus the white population of the United States in 1800 was 4,312,841.[3] This population, without further accession of births, would in 1810 be diminished one eighth, or reduced to 3,773,736. In 1810 the population above ten years of age was 3,845,389; and, subtracting the former number from the latter, the difference, or amount of emigration, will be 71,653, or 7165 a year.

Again, the white population of 1810 was 5,862,092, which, diminished by one eighth in ten years, would be 5,129,331. The population above ten years of age in 1820 was 5,235,940.[4] Subtracting the former from the latter, the difference, or amount of emigration, is 106,608, or 10,660 a year; showing, as we should expect, a greater amount of emigration from 1810 to 1820 than from 1800 to 1810, but, even in the latter ten years, and including emigrations from Canada, as well as all other countries, little exceeding 10,000.

Altogether, then, we can hardly err in defect, if we allow 10,000 a year for the average increase from emigration during the twenty-five years from 1795 to 1820; and applying this number to the slowest period of increase, when the rate was such as to double the population in twenty-three years and seven months, it may be easily calculated, that in the additional year and five months a population of 5,862,000 would have increased to an amount much more than sufficient to cover an annual emigration of 10,000 persons, with the increase from them at the same rate.

Such an increase from them, however, would not take place. It appears from an account in the National Calendar of the United States for the year 1821, that of the 7001 persons who had arrived in America from the 30th of September 1819 to the 30th of September 1820, 1959 only were females, and the rest, 5042, were males; a proportion which, if it approaches towards representing the average, must very greatly reduce the number from which any increase ought to be calculated.

If, however, we omit these considerations; if we suppose a yearly emigration from Europe to America of 10,000 persons for the twenty-five years from 1795 to 1820, the greatest part of which time Europe was involved in a most extensive scene of warfare, requiring all its population; and further, if we allow for an increase of all the emigrants during the *whole period*, at the fullest rate; the remaining numbers will still be sufficient to show a doubling of the population in less than twenty-five years.

The white population of 1790 was 3,164,148. This population, according to the rate at which it was increasing, would have amounted to about 3,694,100 in 1795; and supposing it to have just doubled itself in the twenty-

[1] American National Calendar for 1821, p. 237; and North American Review for October 1822, p. 304.
[2] This mode was suggested by Mr Booth, in Mr Godwin's Answer to Mr Malthus.
[3] Seybert's Statistical Annals, p. 23.
[4] American National Calendar for 1822, p. 246.

Population. five years from 1795 to 1820, the population in 1820 would have been 7,388,200. But the actual white population of 1820 appears, by the census then taken, to be 7,861,710, showing an excess of 473,510; whereas an emigration of 10,000 persons annually, with the increase from them at three per cent., a rate which would double a population in less than twenty-four years, would only amount to 364,592.

But the most striking confirmation of the censuses of the United States, and the most remarkable proof of the rate of increase being occasioned almost exclusively by procreation, have been furnished to us by Mr Milne. In his work on Annuities and Assurances, which contains much valuable and interesting information on the subject of population, he had noticed the effects of the frequent pressure of want on the labouring classes of Sweden, which, by increasing the proportion of deaths, rendered the law of mortality so accurately observed in that country by Professors Wargentin and Nicander inapplicable to other countries more favourably circumstanced. But the law of mortality was observed to be gradually improving from the time that Dr Price constructed his Swedish table; and the period from 1800 to the end of 1805 was so free from scarcities and epidemics, and the healthiness of the country had been further so much improved by the introduction of vaccination, that he justly thought the law of mortality, as observed during these five years, might suit countries where the condition of the people was known to be much better than it had generally been in Sweden. On these grounds he applied the Swedish law of mortality, during the term mentioned, to the hypothesis of a population which had been increasing by procreation, in geometrical progression, for more than a hundred years, so as to double every twenty-five years. Assuming this population to be one million, he distributed it, by a process well known to persons conversant with these subjects, into the different ages referred to in the American censuses, and then compared them with the same number of persons distributed according to the actual returns of the ages in the American censuses for the three periods of 1800, 1810, and 1820. The results are as follows:

Distribution of a Population of 1,000,000 *Persons in the under-mentioned intervals of Age.*

Between the Ages of	According to	United States.		
	The Hypothesis.	Census of 1800.	Census of 1810.	Census of 1820.
0 and 10	337,592	334,556	344,024	333,995
10 and 16	145,583	154,898	156,345	154,913
16 and 26	186,222	185,046	189,227	198,114
26 and 45	213,013	205,289	190,461	191,139
45 and 100	117,590	120,211	119,943	121,839
0 and 100	1,000,000	1,000,000	1,000,000	1,000,000
Under 16	483,175	489,454	500,369	488,908
Above 16	516,825	510,546	499,631	511,092

The general resemblance in the distribution of the ages in the three different censuses to each other, and to the hypothesis, clearly proves,

1*st*, That the distribution of the ages in the different enumerations must be made with some care, and may, therefore, be relied on as in the main correct.

2*dly*, That the law of mortality assumed in the hypothesis cannot deviate essentially from the law of mortality which prevails in the United States; and, Population.

3*dly*, That the actual structure of the American population differs very little from what it would be if it were increasing regularly from procreation only, in geometrical progression, so as to double itself every twenty-five years; and that we may, therefore, safely infer that it has been very little disturbed by immigration.

If to these proofs of the rapid increase of population which has actually taken place, we add the consideration that this rate of increase is an average applying to a most extensive territory, some parts of which are known to be unhealthy; that some of the towns of the United States are now large; that many of the inhabitants must be engaged in unwholesome occupations, and exposed to many of those checks to increase which prevail in other countries; and further, that in the western territories, where these checks do not occur, the rate of increase is beyond comparison more rapid than the general average, after making the fullest allowance for immigration; it must appear certain, that the rate at which the population of the whole of the United States has actually increased for the last thirty years must fall very decidedly short of the actual capacity of mankind to increase under the most favourable circumstances.

The rate of increase in the United States confirmed by that of other countries.

The best proof that can be obtained of the capacity of mankind to increase at a certain rate, is their having really increased at that rate. At the same time, if any peculiarly rapid increase which had appeared to take place in a particular country were quite unsupported by other evidence, we might be disposed to attribute it to error or accident, and might scarcely be justified in founding important conclusions upon it. But this is far from being the case in the present instance. The rate of increase which has at times taken place in other countries, under the operation of great and obvious checks to the progress of population, sufficiently shows what might be expected if these checks were removed.

Increase of population in New Spain.

The countries most resembling the United States of America are those territories of the new world which lately belonged to Spain. In abundance and fertility of soil they are indeed superior; but almost all the vices in the government of the mother country were introduced into her colonial possessions, and particularly that very unequal distribution of landed property which takes place under the feudal system. These evils, and the circumstance of a very large part of the population being Indians in a depressed state, and inferior in industry and energy to Europeans, necessarily prevent that rapid increase of numbers which the abundance and fertility of the land would admit of. But it appears, from the instructive and interesting account of New Spain which M. Humboldt has not long since given to the public, that for the last half of the eighteenth century the excess of the births above the deaths, and the progress of the population, have been very great. The following are the proportions of burials to baptisms in the registers of eleven villages, the details of which were communicated to M. Humboldt by the curates.

	Burials.	Baptisms.
At Dolores	100	253
Singuilucan	100	234
Calymaya	100	202
Guanaxuato	100	201
St Anne	100	195
Marsil	100	194
Queretaro	100	188
Axapuzco	100	157
Yguala	100	140
Malacatepec	100	130
Panuco	100	123

The mean proportion is 100 to 183.

Popula-tion.

But the proportion which M. Humboldt considers as best suited to the whole of the population is 100 to 170.

In some of the villages above mentioned, the proportion of the births to the population is extraordinarily great, and the proportion of deaths very considerable; showing, in a striking point of view, the early marriages and early deaths of a tropical climate, and the more rapid passing away of each generation.[1]

At Queretaro, it appears that the baptisms were to the population as one to fourteen, and the burials as one to twenty-six.

At Guanaxuato, including the neighbouring mines of St Anne and of Marsil, the baptisms were to the population as one to fifteen, and the burials as one to twenty-nine.

The general result from all the information which could be collected was, that the proportion of births to the population, for the whole of the kingdom of New Spain, was as one to seventeen, and of the deaths as one to thirty. These proportions of births to deaths, if they were continued, would double the population in twenty-seven and a half years.

M. Humboldt further observes, that the information which he had collected respecting the proportions of the births to the deaths, and of these to the whole population, proves, that if the order of nature were not interrupted by some extraordinary and disturbing causes, the population of New Spain ought to double itself every nineteen years.[2]

It is known, however, that these causes do occur in the actual state of things; consequently we cannot consider the actual rate of the increase of population in New Spain as greater than according to the former calculation. But a rate of increase such as to double the population in twenty-seven and a half years, in spite of all the obstacles enumerated by M. Humboldt, is very extraordinary. It is next to the increase of the United States, and greatly superior to any that can be found in Europe.

Yet in Europe, the tendency to increase is always very strongly marked, and the actual increase for periods of some length is sometimes much greater than could be expected beforehand, considering the obstacles to be overcome.

It appears from Sussmilch,[3] that the population of Prussia and Lithuania, after the great plague in 1709 and 1710, doubled itself in about forty-four years, from the excess of the births above the deaths enumerated in the registers.

In Russia, the whole population in 1763 was estimated, by enumeration and calculation, at twenty millions, and in 1796 at thirty-six millions.[4] This is a rate of increase which would occasion a doubling in less than forty-two years.

In 1695, the population of Ireland was estimated at 1,034,000. According to the returns in 1821, it had increased to the prodigious amount of 6,846,949;[5] and it is thought that when the deficiencies have been supplied by the final returns of the enumerators, it will be upwards of seven millions. This is an example of an actual increase for 125 years together, at a rate which would double the population in about forty-five years; and this has taken place under the frequent pressure of great distress among the labouring classes of society, and the practice of frequent and considerable emigration.

But for the proof of the power of population to increase under great obstacles of the preventive, as well as of the positive kind, we need not go out of Great Britain. The rate of increase since our enumerations have commenced has been very remarkable for a country which was considered as well peopled before, and some of the details accompanying the returns tend strikingly to illustrate the principle of population.

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Increase of population in Great Britain from 1800 to 1821.

The population of Great Britain, according to the enumerations of 1821 and 1811, was, respectively, 10,942,646 and 12,596,803.[6] This is a rate of increase, during the ten years, of rather above fifteen per cent., a rate which, if continued, would double the population in between forty-nine and fifty years.

By the enumeration of 1821, it appears that the population was 14,391,631,[7] which, compared with the population of 1811, gives a rate of increase during the ten years of 14·25 per cent., a rate which would double the population in about fifty-two years.

According to these numbers, the rate of increase during the last ten years was slower than that of the first; but it appears, from the excess of the number of males above females in the enumeration of 1811, so opposite to the state of the population in 1801 and 1821, when the females exceeded the males, particularly at the latter period, that of the large number added to the population for the army, navy, and registered merchant ships in 1811, a considerable proportion must have been foreigners. On this account, and on account of the further difficulty of knowing what part of this number might properly belong to Ireland, it has been proposed to estimate the rate per cent. at which the population has increased in each of the ten years by the females only; and, according to this mode of computation, the population increased during the first period at the rate of 14·02 per cent., and during the second at the rate of 15·82. (Preliminary Observations, p. 8.) This last rate of increase would double the population in less than forty-eight years.

The only objection to this mode of computation is, that it does not take into consideration the greater destruction of the males during the war. In 1801, the females exceeded the half of the population by 21,031, and in 1821 by 63,890, while, at the intermediate period, owing to the causes above mentioned, the females fell short of the half of the males by 35,685.

When, however, a proper distribution has been made of the army and navy among the resident population, and taking England and Wales alone, it appears that from 1801 to 1811 the population increased at the rate of fourteen and a half per cent., and from 1811 to 1821, at the rate of sixteen and one third per cent. (Preliminary Observations, p. 32.) At the former of these rates, the period of doubling would be rather above fifty years; at the latter, under forty-six years; and, taking the whole period, the time of doubling would be about forty-eight years. Yet in Great Britain there is a much larger proportion of the population living in towns, and engaged in occupations considered as unhealthy, than in any other known country of the same extent. There are also the best reasons for believing that in no other country of the same extent is there to be found so great a proportion of late marriages, or so great a proportion of persons remaining unmarried, as in Great Britain. It is further known that the number of emigrants from Great Britain greatly exceed those who come into the country. And if,

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[1] The details which M. Humboldt has given of the population of New Spain are highly interesting, as they are the first of any consequence which the public has yet received of a tropical climate. The peculiarities which mark them are exactly of the kind which might have been expected, though the proportion of births is still greater than we could have ventured to suppose.

[2] *Essai Politique sur le Royaume de la Nouvelle Espagne*, liv. ii. chap. iv. pp. 330 *et seq.* vol. i. Oct.

[3] *Gottliche Ordnung*, vol. i. table xxi.

[4] Malthus on Population, vol. i. p 439, 5th edit.

[5] Report of the Preliminary Proceedings under Population Act, 58th Geo. III. p. 28.

[6] Population Abstract, 1821; Preliminary Observations, p. 8.

[7] Ibid.

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under these circumstances, a demand for labour and an increase of the funds for its maintenance could for twenty years together occasion such a rate of increase as, if continued, would double the population in forty-eight years, and quadruple it in ninety-six years, it is in the highest degree probable, that if the encouragements to marriage and the means of supporting a family were as great as in America, the period of doubling in Great Britain would not be more than twenty-five years, even in spite of her great towns and manufactories; and would be decidedly less if these obstacles were removed.

The lowest rate of increase that can be assumed for the natural progress of population.

Taking therefore into consideration the actual rate of increase which appears from the best documents to have taken place over a very large extent of country in the United States of America, very variously circumstanced as to healthiness and rapidity of progress; considering, further, the rate of increase which has taken place in New Spain, and also in many countries of Europe, where the means of supporting a family, and other circumstances favourable to increase, bear no comparison with those of the United States; and adverting particularly to the great increase of population which has taken place in this country during the last twenty years, under the formidable obstacles to its progress which must press themselves upon the attention of the most careless observer; it must appear, that the assumption of a rate of increase such as would double the population in twenty-five years, as representing the natural progress of population, when not checked by the difficulty of procuring the means of subsistence, or other peculiar causes of premature mortality, must be very decidedly within the truth.

It may be safely asserted, therefore, that population, when unchecked, increases in a geometrical progression of such a nature as to double itself every twenty-five years.

Different character of the rate of increase in the food of a limited territory.

It would be unquestionably desirable to have the means of comparing the natural rate of the increase of population when unchecked, with the possible rate of the increase of food, in a limited territory, such as that in which man is actually placed; but the latter estimate is much more difficult and uncertain than the former. If the rate of the increase of population at a particular period of some little extent can be ascertained with tolerable exactness, we have only to suppose the continuance of the same encouragements to marriage, the same facility of supporting a family, the same moral habits, with the same rate of mortality; and the increase of the population at the same rate, after it had reached a thousand millions, would be just as probable as at any intermediate and earlier period; but it is quite obvious that the increase of food in a limited space must proceed upon a principle totally different. It has been already stated, that while land of good quality is in great abundance, the rate at which food might be made to increase would far exceed what is necessary to keep pace with the most rapid increase of population which the laws of nature in relation to human kind permit. But if society were so constituted as to give the fullest scope possible to the progress of cultivation and population, all such lands, and all lands of moderate quality, would soon be occupied; and when the future increase of the supply of food came to depend upon the taking of very poor land into cultivation, and the gradual and laborious improvement of the land already cultivated, the rate of the increase of food would certainly have a greater resemblance to a decreasing geometrical ratio than an increasing one. The yearly increment of food would, at any rate, have a constant tendency to diminish, and the amount of the increase of each successive ten years would probably be less than that of the preceding.

Practically, however, great uncertainty must take place. An unfavourable distribution of produce, by prematurely diminishing the demand for labour, might retard the increase of food at an early period, in the same manner as if cultivation and population had been further advanced; while improvements in agriculture, accompanied by a great demand for labour and produce, might for some time occasion a rapid increase of food and population at a later period, in the same manner as if cultivation and population had been in an earlier stage of their progress. These variations, however, obviously arise from causes which do not impeach the general tendency of a continued increase of produce in a limited territory to diminish the power of its increase in future.

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Supposition respecting the power of increasing food.

Under this certainty with regard to the general tendency, and uncertainty in reference to particular periods, it must be allowable, if it throws light on the subject, to make a supposition respecting the increase of food in a limited territory, which, without pretending to accuracy, is clearly more favourable to the power of the soil to produce the means of subsistence for an increasing population, than any experience which we have of its qualities will warrant.

If, setting out from a tolerably well-peopled country, such as England, France, Italy, or Germany, we were to suppose that, by great attention to agriculture, its produce could be permanently increased every twenty-five years by a quantity equal to that which it at present produces, it would be allowing a rate of increase decidedly beyond any probability of realization. The most sanguine cultivators could hardly expect that, in the course of the next two hundred years, each farm in this country on an average would produce eight times as much food as it produces at present, and still less that this rate of increase could continue, so that each farm would produce twenty times as much as at present in five hundred years, and forty times as much in a thousand years. Yet this would be but an arithmetical progression, and would fall short, beyond all comparison, of the natural increase of population in a geometrical progression, according to which the inhabitants of any country, in five hundred years, instead of increasing to twenty times, would increase to above a million times their present numbers.

It will be said, perhaps, that many parts of the earth are as yet very thinly peopled, and, under proper management, would allow of a much more rapid increase of food than would be possible in the more fully inhabited states of Europe. This is unquestionably true. Some parts of the earth would no doubt be capable of producing food at such a rate as to keep pace for a few periods with an unrestricted increase of population. But to put this capacity fully into action, is of all things the most difficult. If it is to be accomplished by the improvement of the actual inhabitants of the different parts of the earth in knowledge, in government, in industry, in arts, and in morals, it is scarcely possible to say how it ought to be commenced with the best prospect of success, or to form a conjecture as to the time in which it could be effected.

Insufficiency of emigration.

If it is to be accomplished by emigration from the more improved parts of the world, it is obvious that it must involve much war and extermination; besides all the difficulties usually attendant upon new settlements in uncivilized countries; and these alone are so formidable, and for a long time so destructive, that, combined with the unwillingness which people must always naturally feel to quit their own country, much distress would be suffered at home before relief would be sought for in emigration.

But, supposing for a moment that the object could be fully accomplished, that is, supposing that the capacity of the earth to produce the necessaries of life could be put fully into action, and that they were distributed in the proportions most favourable for the growth of capital and the effective demand for labour, the increase of population, whether arising from the increase of the inhabitants of each

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country, or from emigrants issuing from all those countries which were more advanced in cultivation, would be so rapid, that, in a period comparatively quite short, all the good lands would be occupied, and the rate of the possible increase of food would be reduced much below the arithmetical ratio above supposed.

If, merely during the short period which has elapsed since our Revolution of 1688, the population of the earth had increased at its natural rate when unchecked, supposing the number of people at that time to have been only eight hundred millions, all the land of the globe, without making allowance for deserts, forests, rocks, and lakes, would on an average be equally populous with England and Wales at present. This would be accomplished in five doublings, or a hundred and twenty-five years; and one or two doublings more, or a period less than that which has elapsed since the beginning of the reign of James I., would produce the same effect from the overflowings of the inhabitants of those countries where, owing to the further progress of cultivation, the soil had not the capacity of producing food so as to keep pace with the increase of an unrestricted population.

Whatever temporary and partial relief, therefore, may be derived from emigration by particular countries in the actual state of things, it is quite obvious, that, considering the subject generally and largely, emigration may be fairly said not in any degree to touch the difficulty. And, whether we exclude or include emigration, whether we refer to particular countries, or to the whole earth, the supposition of a future capacity in the soil to increase the necessaries of life every twenty-five years by a quantity equal to that which is at present produced, must be decidedly beyond the truth.

Effect of the two different rates of increase when brought together.

But if the natural increase of population, when unchecked by the difficulty of procuring the means of subsistence, or other peculiar causes, be such as to continue doubling its numbers in twenty-five years; and the greatest increase of food, which, for a continuance, could possibly take place on a limited territory like our earth in its present state, be at the most only such as would add every twenty-five years an amount equal to its present produce; it is quite clear that a powerful check on the increase of population must be almost constantly in action.

By the laws of nature man cannot live without food. Whatever may be the rate at which population would increase if unchecked, it never can actually increase in any country beyond the food necessary to support it. But, by the laws of nature in respect to the powers of a limited territory, the additions which can be made in equal periods to the food which it produces must, after a short time, either be constantly decreasing, which is what would really take place; or, at the very most, must remain stationary, so as to increase the means of subsistence only in an arithmetical progression. Consequently, it follows necessarily that the average rate of the *actual* increase of population over the greatest part of the globe, obeying the same laws as the increase of food, must be totally of a different character from the rate at which it would increase if *unchecked*.

The great question, then, which remains to be considered, is the manner in which this constant and necessary check upon population practically operates.

General character of the checks to population.

If the soil of any extensive well-peopled country were equally divided amongst its inhabitants, the check would assume its most obvious and simple form. Perhaps each farm in the well-peopled countries of Europe might allow of one, or even two doublings, without much distress, but the absolute impossibility of going on at the same rate is too glaring to escape the most careless thinker. When, by extraordinary efforts, provision had been made for four times the number of persons which the land can support at present, what possible hope could there be of doubling the provision in the next twenty-five years?

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Yet there is no reason whatever to suppose that any thing besides the difficulty of procuring in adequate plenty the necessaries of life, should either indispose this greater number of persons to marry early, or disable them from rearing in health the largest families. But this difficulty would of necessity occur, and its effect would be either to discourage early marriages, which would check the rate of increase by preventing the same proportion of births; or to render the children unhealthy from bad and insufficient nourishment, which would check the rate of increase by occasioning a greater proportion of deaths; or, what is most likely to happen, the rate of increase would be checked, partly by the diminution of births, and partly by the increase of mortality.

The first of these checks may, with propriety, be called the *preventive check* to population; the second, the *positive check*; and the absolute necessity of their operation in the case supposed is as certain and obvious as that man cannot live without food.

Taking a single farm only into consideration, no man would have the hardihood to assert that its produce could be made permanently to keep pace with a population increasing at such a rate as it is observed to do for twenty or thirty years together at particular times and in particular countries. He would, indeed, be compelled to acknowledge, that if, with a view to allow for the most sanguine speculations, it has been supposed that the additions made to the necessaries produced by the soil in given times might remain constant, yet that this rate of the increase of produce could not possibly be realized; and that, if the capacity of the soil were at all times put properly into action, the additions to the produce would, after a short time, and independently of new inventions, be constantly decreasing, till, in no very long period, the exertions of an additional labourer would not produce his own subsistence.

But what is true in this respect in reference to a single farm, must necessarily be true of the whole earth, from which the necessaries of life for the actual population are derived. And what would be true in respect to the checks to population if the soil of the earth were equally divided among the different families which inhabit it, must be true under the present unequal division of property and variety of occupations. Nothing but the confusion and indistinctness arising from the largeness of the subject, and the vague and false notions which prevail respecting the efficacy of emigration, could make persons deny in the case of an extensive territory or the whole earth, what they could not fail to acknowledge in the case of a single farm, which may be said fairly to represent it.

It may be expected, indeed, that in civilized and improved countries the accumulation of capital, the division of labour, and the invention of machinery, will extend the bounds of production; but we know from experience that the effects of these causes, which are quite astonishing in reference to some of the conveniences and luxuries of life, are very much less efficient in producing an increase of food; and although the saving of labour and an improved system of husbandry may be the means of pushing cultivation upon much poorer lands than could otherwise be worked, yet the increased quantity of the necessaries of life so obtained can never be such as to supersede, for any length of time, the operation of the preventive and positive checks to population. And not only are these checks as absolutely necessary in civilized and improved countries, as they would be if each family had a certain portion of land allotted to it, but they operate almost exactly in the same way. The distress which would obviously arise in the most simple state of society, from the natural tendency of population to increase faster than the means of subsistence in a

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limited territory, is brought home to the higher classes of an improved and populous country, in the difficulty which they find in supporting their families in the same rank of life with themselves; and to the labouring classes, which form the great mass of society, in the insufficiency of the real wages of common labour to bring up a large family.

If in any country the yearly earnings of the commonest labourers, determined, as they always will be, by the state of the demand and the supply of necessaries compared with labour, be not sufficient to bring up in health the largest families, one of the three things before stated must happen; either the prospect of this difficulty will prevent some and delay other marriages; or the diseases arising from bad nourishment will be introduced, and the mortality be increased; or the progress of population will be retarded, partly by one cause and partly by the other.

Of the effect of private property on the progress of population.

According to all past experience, and the best observations which can be made on the motives which operate upon the human mind, there can be no well-founded hope of obtaining a large produce from the soil, but under a system of private property. It seems perfectly visionary to suppose that any stimulus short of that which is excited in man by the desire of providing for himself and family, and of bettering his condition in life, should operate on the mass of society with sufficient force and constancy to overcome the natural indolence of mankind. All the attempts which have been made since the commencement of authentic history to proceed upon a principle of common property, have either been so insignificant that no inference can be drawn from them, or have been marked by the most signal failures; and the changes which have been effected in modern times by education do not seem to advance a single step towards making such a state of things more probable in future. We may therefore safely conclude, that while man retains the same physical and moral constitution which he is observed to possess at present, no other than a system of private property stands the least chance of providing for such a large and increasing population as that which is to be found in many countries at present.

But though there is scarcely any conclusion which seems more completely established by experience than this, yet it is unquestionably true that the laws of private property, which are the grand stimulants to production, do themselves so limit it, as always to make the actual produce of the earth fall very considerably short of the *power* of production. On a system of private property no adequate motive to the extension of cultivation can exist, unless the returns are sufficient, not only to pay the wages necessary to keep up the population, which, at the least, must include the support of a wife and two or three children, but also afford a profit on the capital which has been employed. This necessarily excludes from cultivation a considerable portion of land, which might be made to bear corn. If it were possible to suppose that man might be adequately stimulated to labour under a system of common property, such land might be cultivated, and the production of food and the increase of population might go on, till the soil absolutely refused to grow a single additional quarter, and the whole of the society was exclusively engaged in procuring the necessaries of life. But it is quite obvious that such a state of things would inevitably lead to the greatest degree of distress and degradation. And if a system of private property secures mankind from such evils, which it certainly does in a great degree, by securing to a portion of the society the leisure necessary for the progress of the arts and sciences, it must be allowed that such a check to the increase of cultivation confers on society a most signal benefit.

But it must perhaps also be allowed, that, under a system of private property, cultivation is sometimes checked in a degree and at a period not required by the interest of society. And this is particularly likely to happen when the original divisions of land have been extremely unequal, and the laws have not given sufficient facility to a better distribution of them. Under a system of private property, the only effectual demand for produce must come from the owners of property; and though it be true that the effectual demand of the society, whatever it may be, is best supplied under the most perfect system of liberty, yet it is not true that the tastes and wants of the effective demanders are always, and necessarily, the most favourable to the progress of national wealth. A taste for hunting and the preservation of game among the owners of the soil will, without fail, be supplied, if things be allowed to take their natural course; but such a supply, from the manner in which it must be effected, would inevitably be most unfavourable to the increase of produce and population. In the same manner, the want of an adequate taste for the consumption of manufactured commodities among the possessors of surplus produce, if not fully compensated by a great desire for personal attendance, which it never is, would infallibly occasion a premature slackness in the demand for labour and produce, a premature fall of profits, and a check to cultivation.

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It makes little difference in the actual rate of the increase of population, or the necessary existence of checks to it, whether that state of demand and supply which occasions an insufficiency of wages to the whole of the labouring classes be produced prematurely by a bad structure of society and an unfavourable distribution of wealth, or necessarily by the comparative exhaustion of the soil. The labourer feels the difficulty nearly in the same degree, and it must have nearly the same results, from whatever cause it arises; consequently, in every country with which we are acquainted, where the yearly earnings of the labouring classes are not sufficient to bring up in health the largest families, it may be safely said that population is actually checked by the difficulty of procuring the means of subsistence. And, as we well know that ample wages, combined with full employment for all who choose to work, are extremely rare, and scarcely ever occur, except for a certain time, when the knowledge and industry of an old country is applied, under favourable circumstances, to a new one; it follows that the pressure arising from the difficulty of procuring subsistence is not to be considered as a remote one, which will be felt only when the earth refuses to produce any more, but as one which not only actually exists at present over the greatest part of the globe, but, with few exceptions, has been almost constantly acting upon all the countries of which we have any account.

It is unquestionably true, that, in no country of the globe have the government, the distribution of property, and the habits of the people, been such as to call forth, in the most effective manner, the resources of the soil. Consequently, if the most advantageous possible change in all these respects could be supposed at once to take place, it is certain that the demand for labour and the encouragement to production might be such as for a short time in some countries, and for rather a longer in others, to lessen the operation of the checks to population which have been described. It is specifically this truth constantly obtruding itself upon our attention which is the great source of delusion on this subject, and creates the belief that man could always produce from the soil much more than sufficient to support himself and family. In the actual state of things this power has perhaps always been possessed. But for it we are indebted wholly to the ignorance and bad government of our ancestors. If they had properly called forth the resources of the soil, it is quite certain that we should now have but scanty means left of further increasing our food. If merely since the time of William the Conqueror all the nations of the earth had been well governed, and if the distribution of

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property, and the habits both of the rich and the poor, had been the most favourable to the demand for produce and labour, though the amount of food and population would have been prodigiously greater than at present, the means of diminishing the checks to population would unquestionably be less. That difficulty in procuring the necessaries of life which is now felt in the comparatively low wages of labour almost all over the world, and is occasioned partly by the necessary state of the soil, and partly by a premature check to the demand for produce and labour, would then be felt in a greater degree, and would less admit of any relaxation in the checks to population, because it would be occasioned wholly and necessarily by the state of the soil.

The laws of nature responsible for the necessity of checks to population.

It appears, then, that what may be called the proportionate amount of the necessary checks to population depends very little upon the efforts of man in the cultivation of the soil. If these efforts had been directed from the first in the most enlightened and efficient manner, the checks necessary to keep the population on a level with the means of subsistence, so far from being lightened, would in all probability be operating with greater force; and the condition of the labouring classes, so far as it depends on the facility of procuring the means of subsistence, instead of being improved, would in all probability be deteriorated.

It is to the laws of nature, therefore, and not to the conduct and institutions of man, that we are to attribute the necessity of a strong check on the natural increase of population.

Man responsible for the prevailing character of these checks.

But though the laws of nature which determine the rate at which population would increase if unchecked, and the very different rate at which the food required to support population could be made to increase in a limited territory, are undoubtedly the causes which render necessary the existence of some great and constant check to population, yet a vast mass of responsibility remains behind on man and the institutions of society.

In the first place, they are certainly responsible for the present scanty population of the earth. There are few large countries, however advanced in improvement, the population of which might not have been doubled or tripled, and there are many which might be ten, or even a hundred times as populous, and yet all the inhabitants be as well provided for as they are now, if the institutions of society and the moral habits of the people had been for some hundred years the most favourable to the increase of capital, and the demand for produce and labour.

Secondly, though man has but a trifling and temporary influence in altering the proportionate amount of the checks to population, or the degree in which they press upon the actual numbers, yet he has a great and most extensive influence on their character and mode of operation.

It is not in superseding the necessity of checks to population, in the progress of mankind to the full peopling of the earth (which may with truth be said to be a physical impossibility), but in directing these checks in such a way as to be the least prejudicial to the virtue and happiness of society, that government and human institutions produce their great effect. Here we know, from constant experience, that they have great power. Yet even here it must be allowed that the power of government is rather indirect than direct, as the object to be attained depends mainly upon such a conduct on the part of individuals as can seldom be directly enforced by laws, though it may be powerfully influenced by them.

This will appear if we consider more particularly the nature of those checks which have been classed under the general heads of Preventive and Positive.

It will be found that they are all resolvable into *moral restraint*, *vice*, and *misery*. And if, from the laws of nature, some check to the increase of population be absolutely inevitable, and human institutions have any influence upon the extent to which each of these checks operates, a heavy responsibility will be incurred, if all that influence, whether direct or indirect, be not exerted to diminish the amount of vice and misery.

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These checks resolvable into moral restraint, vice, and misery.

Moral restraint, in application to the present subject, may be defined to be, abstinence from marriage, either for a time or permanently, from prudential considerations, with a strictly moral conduct towards the sex in the interval. And this is the only mode of keeping population on a level with the means of subsistence, which is perfectly consistent with virtue and happiness. All other checks, whether of the preventive or the positive kind, though they may greatly vary in degree, resolve themselves into some form of vice or misery.

The remaining checks of the preventive kind, are the sort of intercourse which renders some of the women of large towns unprolific; a general corruption of morals with regard to the sex, which has a similar effect; unnatural passions, and improper arts to prevent the consequences of irregular connections. These evidently come under the head of vice.

The positive checks to population include all the causes which tend in any way prematurely to shorten the duration of human life; such as unwholesome occupations, severe labour and exposure to the seasons, bad and insufficient food and clothing, arising from poverty, bad nursing of children, excesses of all kinds, great towns and manufactories, the whole train of common diseases and epidemics, wars, infanticide, plague, and famine. Of these positive checks, those which appear to arise from the laws of nature may be called exclusively misery; and those which we bring upon ourselves, such as wars, excesses of all kinds, and many others, which it would be in our power to avoid, are of a mixed nature. They are brought upon us by vice, and their consequences are misery.

Some of these checks, in various combinations, and operating with various force, are constantly in action in all the countries with which we are acquainted, and form the immediate causes which keep the population on a level with the means of subsistence.

Mr Malthus, in his work on this subject, has taken a view of the checks of population in most of the countries of which we have the best accounts. His object was evidently to trace in each country those checks which appeared to be most effective in repressing population; and to endeavour to answer the question generally which had been applied particularly to New Holland by Captain Cook, namely, By what means is the population of this country kept down to the number which it can subsist?

Prudential restraint on marriage.

It was hardly to be expected, however, that the general accounts of countries which are to be met with should contain a sufficient number of details of the kind required to enable us to ascertain what portion of the natural increase of population each individual check which could be traced had the power to overcome. In particular, it was not to be expected, that any accounts could inform us of the degree in which moral restraint prevails when taken in its strictest sense. It is necessary, therefore, to attend chiefly to the greater or smaller number of persons who remain unmarried, or marry late; and the delay of marriage, owing to the difficulty of providing for a family, when the degree of irregularity to which it may lead cannot be ascertained, may be usefully called the prudential restraint on marriage and population. And this will be found to be the chief mode in which the preventive check practically operates.

But if the preventive check to population, that check which can alone supersede great misery and mortality, operates chiefly by a prudential restraint on marriage, it will be obvious, as was before stated, that direct legislation cannot do much. Prudence cannot be enforced by laws, with-

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Causes which principally affect the habits of the labouring classes.

out a great violation of natural liberty, and a great risk of producing more evil than good. But still the very great influence of a just and enlightened government, and the perfect security of property in creating habits of prudence, cannot for a moment be questioned. The principal causes and effects of these habits are thus stated in Mr Malthus's last work.[1]

"From high wages, or the power of commanding a large portion of the necessaries of life, two very different results may follow; one, that of a rapid increase of population, in which case the high wages are chiefly spent in the maintenance of large and frequent families; and the other, that of a decided improvement in the modes of subsistence, and the conveniences and comforts enjoyed, without a proportionate acceleration in the rate of increase.

"In looking to these different results, the causes of them will evidently appear to be the different habits existing among the people of different countries, and at different times. In an inquiry into the causes of these different habits, we shall generally be able to trace those which produce the first result to all the circumstances which contribute to depress the lower classes of the people, which make them unable or unwilling to reason from the past to the future, and ready to acquiesce, for the sake of present gratification, in a very low standard of comfort and respectability; and those which produce the second result, to all the circumstances which tend to elevate the character of the lower classes of society, which make them approach the nearest to beings who "look before and after," and who, consequently, cannot acquiesce patiently in the thought of depriving themselves and their children of the means of being respectable, virtuous, and happy.

"Among the circumstances which contribute to the character first described, the most efficient will be found to be despotism, oppression, and ignorance; among those which contribute to the latter character, civil and political liberty, and education.

"Of all the causes which tend to encourage prudential habits among the lower classes of society, the most essential is unquestionably civil liberty. No people can be much accustomed to form plans for the future, who do not feel assured that their industrious exertions, while fair and honourable, will be allowed to have free scope; and that the property which they either possess or may acquire will be secured to them by a known code of just laws impartially administered. But it has been found by experience, that civil liberty cannot be permanently secured without political liberty; consequently political liberty becomes almost equally essential, and, in addition to its being necessary in this point of view, its obvious tendency to teach the lower classes of society to respect themselves, by obliging the higher classes to respect them, must contribute greatly to all the good effects of civil liberty."

"With regard to education, it might certainly be made general under a bad form of government, and might be very deficient under one in other respects good; but it must be allowed that the chances, both with regard to its quality and its prevalence, are greatly in favour of the latter. Education alone could do little against insecurity of property; but it would powerfully assist all the favourable consequences to be expected from civil and political liberty, which could not indeed be considered as complete without it."

The varying prevalence of these habits, owing to the causes above referred to, combined with the smaller or greater mortality occasioned by other customs, and the varying effects of soil and climate, must necessarily produce great differences in different countries, and at different periods, in the character of the predominant checks to population, and the force of each. And this inference, which inevitably follows from theory, is fully confirmed by experience.

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The positive checks to population predominated in ancient times.

It appears, for instance, from the accounts we have received of ancient nations, and of the less civilized parts of the world, that war and violent diseases were the predominant checks to their population. The frequency of wars, and the dreadful devastations of mankind occasioned by them, united with the plagues, famines, and mortal epidemics of which there are records, must have caused such a consumption of the human species, that the exertion of the utmost power of increase must, in many cases, have been insufficient to supply it; and we see at once the source of those encouragements to marriage, and efforts to increase population, which, with inconsiderable exceptions, distinguished the legislation and general policy of ancient times. Yet there were some few men of more extended views, who, when they were looking to the settlement of a society in a more improved state, were fully aware, that under the most beautiful form of government which their imagination could conceive, the greatest poverty and distress might be felt from a too rapid increase of population. And the remedies which they proposed were strong and violent in proportion to the greatness of the evil which they apprehended. Even the practical legislators who encouraged marriage, seemed to think that the supplies of children might sometimes follow too rapidly for the means of supporting them; and it appears to have been with a view to provide against this difficulty, and of preventing it from discouraging marriage, that they frequently sanctioned the inhuman practice of infanticide.

Under these circumstances, it is not to be supposed that the prudential restraint on marriage should have operated to any considerable extent. Except in a few cases where a general corruption of morals prevailed, which might act as a preventive check of the most vicious kind, a large portion of the procreative power was called into action, the occasional redundancy from which was checked by violent causes. These causes will be found resolvable almost wholly into vice and misery; the first of which, and a large portion of the second, it is always in the power of man to avoid.

Prudential restraint the predominant check to population in modern times.

In a review of the checks to population in the different states of modern Europe, it appears that the positive checks to population have prevailed less, and the preventive checks more, than in ancient times, and in the more uncultivated parts of the world. The destruction occasioned by war has unquestionably abated, both on account of its occurring, on the whole, less frequently, and its ravages not being so fatal, either to man or the means of his support, as they were formerly. And although, in the earlier periods of the history of modern Europe, plagues, famines, and mortal epidemics were not unfrequent, yet, as civilization and improvement have advanced, both their frequency and their mortality have been greatly reduced, and in some countries they are now almost unknown. This diminution of the positive checks to population, as it has been certainly much greater in proportion than the actual increase of food and population, must necessarily have been accompanied by an increasing operation of the preventive checks; and probably it may be said with truth, that in almost all the more improved countries of modern Europe, the principal check which at present keeps the population down to the level of the actual means of subsistence, is the prudential restraint on marriage.

Yet in comparing together the accounts and registers of the different countries of modern times, we shall still find a vast difference in the character and force of the checks which are mainly in action; and it is precisely in this point

[1] Principles of Political Economy, c. iv. sect. 2.

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Difference in the character and force of the checks in different countries.

of view that these accounts afford the most important instruction. Some parts of Europe are yet in an unimproved state, and are still subject to frequent plagues and mortal epidemics. In these countries, as might be expected, few traces are to be found of the prudential restraint on marriage. But even in improved countries, the circumstances may be such as to occasion a great mortality. Large towns are known to be unfavourable to health, particularly to the health of young children; and the unwholesomeness of marshy situations may be such as in some cases to balance the principle of increase, even when nearly the whole of the procreative power is called into action, which is seldom the case in large towns.

Thus, in the registers of twenty-two Dutch villages given by Sussmilch,[1] and quoted by Mr Malthus, the mortality (occasioned, as may be supposed, chiefly by the natural unhealthiness of the country) was as high as one in twenty-two or twenty-three, instead of the more common proportion of one in thirty-five or forty; and the consequence was, that the marriages, instead of being in the usual proportion of one in about 108 of the population, were in the extraordinary high proportion of one in sixty-four;[2] showing a most unusual frequency of marriage, while, on account of the great mortality, the number of inhabitants was nearly stationary, and the births and deaths about equal.

On the other hand, in Norway, where the climate and modes of living seem to be extremely favourable to health, and the mortality was only one in forty-eight, the prudential restraint on marriage was called more than usually into action, and the marriages were only one in 130 of the population.

Gradual diminution in the proportion of marriages.

These may be considered as extreme cases, but the same result in different degrees is observable in the registers of all countries; and it is particularly to be remarked, that in those countries where registers of births, deaths, and marriages have been kept for a considerable time, the progressive diminution or mortality occasioned by the introduction of habits more favourable to health, and the consequent diminution of plagues and mortal epidemics, have been accompanied invariably by a smaller proportion of marriages and births. Sussmilch has given some striking instances of the gradual diminution in the proportion of the number of marriages during a part of the last century.[3]

In the town of Leipsic, in the year 1620, the annual marriages were to the population as 1 to 82; from the year 1741 to 1756, they were as 1 to 120.

In Augsburg, in 1510, the proportion of marriages to the population was 1 in 86; in 1750 as 1 to 123.

In Dantzic, in the year 1705, the proportion was as 1 to 89; in 1745, as 1 to 118.

In the dukedom of Magdeburg, in 1700, the proportion was as 1 to 87; from 1752 to 1755, as 1 to 125.

In the principality of Halberstadt, in 1690, the proportion was as 1 to 88; in 1756, as 1 to 112.

In the dukedom of Cleves, in 1705, the proportion was as 1 to 83; in 1755, as 1 to 100.

In the churmark of Brandenburg, in 1700, the proportion was as 1 to 76; and in 1755, as 1 to 108.

Instances of this kind are numerous, and they tend to show the dependence of the marriages on the deaths in all old countries. A greater mortality almost invariably produces a greater number of marriages; and it must be equally certain, that except where the means of subsistence can be adequately increased, a greater proportion of marriages must occasion a greater mortality.

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Dependence of the births and marriages on the deaths.

The proportion of yearly births to the whole population must evidently depend principally on the proportion of marriages; and it appears, consequently, from registers, that in countries which will not admit of any considerable increase of population, the births, as well as the marriages, are mainly influenced by the deaths. When an actual decrease of population is not taking place, the births will always supply the vacancies made by death, and exactly so much more as the increasing wealth of the country and the demand for labour will admit. Everywhere in the intervals of plagues, epidemics, and destructive wars, the births considerably exceed the deaths; but while from these and other causes the mortality in different countries is extremely various, it appears from registers that, with the exception above stated, the births vary in the same proportion.[4]

Thus, in 39 villages of Holland, where the deaths, at the time to which the registers refer, were about 1 in 23, the births were also 1 in 23. In 15 villages round Paris, the births bore the same or even a greater proportion to the whole population, on account of a still greater mortality, the births being 1 in $22\frac{7}{10}$ths, and the deaths the same. In the small towns of Brandenburg, which were in an increasing state, the mortality was 1 in 29, and the births 1 in $24\frac{7}{10}$ths. In Sweden, where the mortality was about 1 in $34\frac{1}{2}$, the births were 1 in 28. In 1056 villages of Brandenburg, in which the mortality was about 1 in 39 or 40, the births were about 1 in 30. In Norway, where the mortality was 1 in 48, the births were 1 in 34.

In all these instances the births are evidently measured by the deaths, after making a proper allowance for the excess of births which the state of each country will admit. In such a country as Russia, this allowance must be great; as, although the mortality might perhaps be taken as low as 1 in 48 or 50, the births were as high as 1 in 26, owing to the increasing resources of the country, which admit of a rapid increase of the population.

Dependence of the births on the deaths illustrated in Switzerland.

Of all the countries which Mr Malthus has reviewed, there is none which so strikingly illustrates the most important fact of the dependence of the proportions of marriages and births on the deaths, and the general principles of population, as Switzerland. It appears, that between 1760 and 1770, an alarm prevailed respecting the continued depopulation of the country; and, to ascertain the point, M. Muret, minister of Vevay, made a very laborious and careful search into the registers of different parishes from the time of their first establishment. He compared the number of births which had taken place during three different periods of seventy years each, the first ending in 1620, the second in 1690, and the third in 1760. And finding by this comparison, that the number of births was less in the second period than in the first, and less in the third period than in the second, he considered the evidence of a continued depopulation of the country from the year 1055 as incontrovertible.[5] But the accounts which he himself produces clearly show, that, in the earlier periods to which he refers, the mortality was very much greater than in the latter; and that the greater *number* of births found in the registers formerly, was not owing to a greater population, but to the greater *proportion* of births which always accompanies a greater mortality.

It appears from accounts which are entirely to be depended on, that during the last period the mortality was extraordinarily small, and the proportion of children reared from infancy to puberty extraordinarily great. At the time when M. Muret wrote his paper, in 1766, the proportion of

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[1] *Gottliche Ordnung*, vol. i. c. iv. s. 57, p. 128. Malthus' Essay on Population, b. ii. c. iv. p. 444 of vol. i. fifth edition.

[2] This very large proportion of marriages could not all have been supplied from the births in the country, but must have been occasioned in part by the influx of strangers.

[3] *Gottliche Ordnung*, vol. i. p. 134 *et seq.*

[4] Sussmilch, *Gottliche Ordnung*, vol. i. p. 225. Essay on Population, vol. i. p. 456, fifth edition.

[5] *Mémoires, &c. par la Société Economique de Berne*, 1766, pp. 15 *et seq.* Essay on Population, vol. i. pp. 464 *et seq.* fifth edition.

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deaths to the population in the Pays de Vaud was 1 in 45, of births 1 in 36, and of marriages 1 in 140. These are all very small proportions of births, deaths, and marriages, compared with other countries; but the state of things must have been totally different in the sixteenth and seventeenth centuries. M. Muret gives a list of all the plagues which had prevailed in Switzerland from 1520, from which it appears that this dreadful scourge desolated the country at short intervals during the whole of the first period, and extended its occasional ravages to within twenty-two years of the termination of the second. We may safely conclude, that, in these times, the average mortality was very much greater than at present. But what puts the question beyond a doubt, is the great mortality which prevailed in the neighbouring town of Geneva in the sixteenth century, and its gradual diminution in the seventeenth and eighteenth. It appears from calculations, published in the *Bibliothèque Britannique* (tom. iv. p. 328), that in the sixteenth century the probability of life, or the age to which half of the born lived, was only 4·883, or under four years and eleven months; and the mean life, or the average number of years due to each person, 18·511, or about eighteen years and a half. In the seventeenth century, the probability of life in Geneva was 11·607, about eleven years and seven months; the mean life 23·358, or twenty three years and four months. In the eighteenth century, the probability of life had increased to 27·183, twenty-seven years and two months; and the mean life to thirty-two years and two months.

There can be no doubt, from the prevalence of the plague, and its gradual extinction, as noticed by M. Muret, that a diminution of mortality of the same kind, though not perhaps to the same extent, must have taken place in Switzerland; but if, with a mortality which could not have been less than one in thirty or thirty-two, the proportion of births had been what it was when M. Muret wrote, it is quite evident that the country would have been rapidly depopulated. But as it is known, from the actual amount of births found in the registers, that this was not the case, it follows as a necessary consequence, that the greater mortality of former times was accompanied by a greater proportion of births. And this at once shows the error of attempting to determine the actual population, either of different countries, or of different periods in the same country, by the amount of the births; and the strong tendency of population to fill up all vacancies, and very rarely to be limited by any other cause than the difficulty of supporting a family.

Swizerland and the Pays de Vaud afford other most striking instances of the dependence of the births on the deaths; and the accounts of them are perhaps more to be depended upon, as they appear to contradict the preconceived opinions of the person who collected them.

Speaking of the want of fruitfulness in the Swiss women, M. Muret says, that Prussia, Brandenburg, Sweden, France, and indeed every country the registers of which he had seen, give a greater proportion of baptisms to the number of inhabitants than the Pays de Vaud, where this proportion is only as 1 to 36. He adds, that from calculations lately made in the Lyonnois, it appeared that in Lyons itself the proportion of baptisms was 1 in 28, in the small towns 1 in 25, and in the villages 1 in 23 or 24. What a prodigious difference, he exclaims, between the Lyonnois and the Pays de Vaud, where the most favourable proportion, and that only in two small parishes of extraordinary fecundity, is not above 1 in 26, and in many parishes it is considerably less than 1 in 40. The same difference, he remarks, takes place in the mean life. In the Lyonnois it is little above 25 years; while in the Pays de Vaud, the lowest mean life, and that only in a single marshy and unhealthy parish, is 29½ years, and in many places it is above 45 years.

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"But whence comes it," he says, "that the country where children escape the best from the dangers of infancy, and where the mean life, in whatever way the calculation is made, is higher than in any other, should be precisely that in which the fecundity is the smallest? How comes it, again, that, of all our parishes, the one which gives the mean life the highest should also be the one where the tendency to increase is the smallest?"[1]

To resolve this question, M. Muret says, "I will hazard a conjecture, which, however, I give only as such. Is it not that, in order to maintain in all places a proper equilibrium of population, God has wisely ordered things in such a manner as that the force of life in each country should be in the inverse ratio of its fecundity? In fact, experience verifies my conjecture. Leyzin, a village in the Alps, with a population of 400 persons, produces but a little above eight children a year. The Pays de Vaud, in general, in proportion to the same number of inhabitants, produces eleven, and the Lyonnois sixteen. But if it happen, that at the age of twenty years, the eight, the eleven, and the sixteen are reduced to the same number, it will appear that the force of life gives in one place what fecundity does in another. And thus the most healthy countries, having less fecundity, will not over-people themselves, and the unhealthy countries, by their extraordinary fecundity, will be able to sustain their population."

These facts and observations are full of the most important instruction, and strikingly illustrate the principle of population. The three gradations in the proportions of births which are here so distinctly presented to our view, may be considered as representing that variety in the proportion of births which is known to take place in different countries and at different periods; and the practical question is, whether, when this variety prevails without a proportionate difference in the rate of increase, which is almost universally the case, we are to suppose, with M. Muret, that a special providence is called into action to render women less prolific in healthy countries, and where improved habits of cleanliness have banished plagues and mortal epidemics; or to suppose, as experience warrants, that the smaller mortality of healthy and improved countries is balanced by the greater prevalence of the prudential restraint on marriage and population.

The subject is seen with particular clearness in Switzerland, on account of the population of some of the districts being stationary. The number of inhabitants on the Alps was supposed to have diminished. This was probably an error; but it is not improbable that they should have remained stationary, or nearly so. There is no land so little capable of providing for an increasing population as mountainous pastures. When they have been once fully stocked with cattle, little more can be done; and if there be neither emigration to take off the superabundant numbers, nor manufactures wherewith to purchase an additional quantity of food, the deaths must equal the births.

This was the case with the Alpine parish of Leyzin before referred to, where, for a period of thirty years, the mortality and the proportion of births almost accurately kept pace with each other; and where, in consequence, if the positive checks to population had been unusually small, the preventive checks must have been unusually great. In the parish of Leyzin, according to M. Muret, the probability of life was as high as sixty-one years;[2] but it is obvious that this extraordinary degree of healthiness could not *possibly* have taken place under the actual circumstances of

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[1] *Mémoires, &c. par la Société Economique de Berne*, 1766, pp. 48 *et seq.*

[2] *Ibid.* table v. p. 65 of the tables.

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the parish with respect to the means of subsistence, if it had not been accompanied by a proportionate action of the prudential restraint on marriage; and accordingly the subsisting marriages, being late and unprolific, yielded only one birth to every twelve; the births were only one in forty-nine, and the number of persons below sixteen was only one fourth of the population.

There can be little doubt that in the present case the extreme healthiness of the people, arising from their situation and employments, had more effect in producing the prudential check to population than the prudential check in producing the extreme healthiness; yet it is quite certain that they must constantly act and re-act upon each other, and that if, when the circumstances are such as to furnish no adequate means for the support of an increased population, and no relief in emigration, the prudential check does not prevail, no degree of natural healthiness could prevent an excessive mortality. Yet to occasion such a mortality, a much greater degree of poverty and misery must have taken place than in districts less favourably circumstanced with regard to health; and we see at once the reason why, in countries of mountainous pasture, if there be no vent in emigration, the necessity of the prudential check should be more strongly forced on the attention of the inhabitants, and should in consequence prevail to a greater degree.

Differences in the registers of different countries.

Taking countries in general, there will necessarily be differences as to natural healthiness in all the gradations, from the most marshy habitable situations to the most pure and salubrious air. These differences will be further increased by the nature of the employments of the people, their habits of cleanliness, and their care in preventing the spread of epidemics. If in no country was there any difficulty in obtaining the means of subsistence, these different degrees of healthiness would make a great difference in the progress of population; and as there are many countries naturally more healthy than the United States of America, we should have instances of a more rapid increase than that which has there taken place. But as the actual progress of population is, with very few exceptions, determined by the relative difficulty of procuring the means of subsistence, and not by the relative natural powers of increase, it is found by experience that, except in extreme cases, the actual progress of population is little affected by unhealthiness or healthiness; but that these circumstances show themselves most powerfully in the character of the checks which keep the population down to the level of the means of subsistence, and occasion that sort of variety in the registers of different countries which was noticed in the instances mentioned by M. Muret.

Thus the population of two or three countries may be increasing at nearly the same rate, but one may be increasing chiefly from a great proportion of births, another from a small proportion of deaths, and a third from a more common proportion of both, in which three different cases the structure of the population, and the registers of births, deaths, and marriages, will be essentially different.

The rate at which the population of Sweden and Norway was increasing, at the time referred to by Mr Malthus, was not far from the same; but their registers differed in almost all points. While the births in Sweden were 1 in 28 of the population, the births in Norway were only 1 in 34; while the marriages in Sweden were 1 in 112, in Norway they were only 1 in 130; and while the mortality in Sweden was 1 in 34½, in Norway it was only 1 in 48.[1] These different proportions of births, deaths, and marriages, must essentially alter the whole structure of the population. The proportion of persons living at different ages would be essentially different; the generations in one country would pass away sooner than the generations in the other; and Sweden might be said to increase principally from the large proportion of its births, and Norway from the small proportion of its deaths, or its small mortality.

A large proportion of births, when they have room to expand themselves, is the most powerful element of increase, and is absolutely necessary in order to effect the shortest period of doubling with which we are acquainted; but two countries may have nearly the same proportion of births, and yet the population of one be quite stationary, while the population of the other is increasing with the greatest known rapidity. The proportion of births in the Dutch villages first noticed approaches towards that of the United States of America; yet in the one case the population did not increase at all, and in the other it has increased so fast as to be taken as a specimen of the natural progress of population when interrupted by the fewest checks to which human society is subject. In this case, though the proportions of births and marriages to the whole population might not be very unlike, and possibly no very great difference might appear in the proportion of marriages to births, the other points in the registers would be in the opposite extremes. While the mortality in the Dutch villages was as high as 1 in 22, it would probably be 1 in 41, or less, in the United States. While the births and deaths in the Dutch villages were in the ratio of equality, in the United States they would be nearly in the proportion of 41 to 19.

In the same manner, two countries might have nearly the same mortality, and yet, in other points, be very different; and while one was increasing most rapidly, the other might be increasing very slowly. The proportion of deaths to the population in the Pays de Vaud is not very essentially different from that of the United States, but the proportion of births and the structure of the population present the most striking contrasts. The proportion of births for the whole of the Pays de Vaud was, according to M. Muret, 1 in 36, in many parishes it was considerably less than 1 in 40, and in one parish as low as 1 in 49; while, in the United States, it must be somewhere between 1 in 19 and 1 in 20. The structure of the population was different accordingly. In the whole of the Pays de Vaud, the proportion of the population under sixteen was one third; in many parts, and in the whole of the Canton of Berne, one fourth; while in the United States, it is as high as one half.

Variations in the age to which half of the born live in different countries.

We have seen, that, according to M. Muret, the probability of life, or the age to which half the born live, was, in the extraordinary parish of Leyzin, as high as 61 years. On the same authority, it appears that in nine other parishes of the Alps it was as high as 47; in 41 parishes of the Pays de Vaud and Jura 42; in 12 corn parishes 40; in 18 parishes among the great vineyards 37, in one marshy parish 24.[2] From other authorities we learn, that in country villages and parishes, the age to which half of the born live is such, that the major part will probably live to marry.[3] In the parish of Ackworth, in Yorkshire, it appears from an exact account kept by Dr Lee, of the ages at which all died there for twenty years from 1747 to 1767, that half the inhabitants live to the age of 46 (Price, vol. ii. p. 35, 7th edit.); and if the same account had been kept in many of the other healthy parishes in England, where the yearly mortality, instead of being 1 in 47 as in Ackworth, was 1 in 60, 1 in 66, and even 1 in 75 (vol. ii. p. 224), half of the born would be found to have lived to above 50 or 55. In

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[1] See Malthus on Population, chapters i. and ii. of book ii.

[2] *Mémoires, &c. par la Société Economique de Berne*, 1766, table viii. p. 92 of the tables. As these calculations seem all to have been made from mortuary registers, they are all too low, except where the population was absolutely stationary.

[3] Graunt's and Short's Observations, &c. referred to by Dr Price, vol. ii. pp. 41, 42, &c. 7th edition.

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the whole of Sweden, where the annual mortality, at the time referred to by Dr Price, was greater than 1 in 35, it appears from his tables, that half of the born must have lived to above 33 (vol. ii. p. 413, 7th edit.); and in Great Britain generally, where the mortality at present, after making due allowance for the omissions in the deaths, appears to be less than 1 in 51, it cannot be doubted that there is scarcely a village in the country tolerably well situated, where half of the born do not live till above 40. In towns the case is very different. According to the data collected by Dr Price, one half of the born died in London under three years of age, in Vienna and Stockholm under two, in Manchester under five, in Northampton under ten (vol. ii. p. 33); and although in most of these towns, particularly those in England, a great improvement has taken place in their healthiness of late years, yet still they will always fall far short of the healthiness of country situations.

The age to which half the born live appears, therefore, to vary in different countries and places, and under different circumstances, in the very extraordinary degree of from 3 to 60.[1]

Variations in the expectation of life in different countries.

The mean age of death, or the expectation of life, must necessarily be more steady; yet it appears to vary from about 16 or 17 to 50.

In Stockholm, according to a table calculated by Dr Price, from the medium of three different enumerations in 1757, 1760, and 1763, the expectation of life for males at birth was 14·25, and for females 18·10.[2] Taken together, the expectation of life was a little above 16. In Vienna, as appears from another table, it was $16\frac{1}{2}$.[3] While, according to M. Muret, at Leyzin, the expectation of life at birth was, about the same period, 50 years.[4]

Variations in the annual mortality.

The annual mortality, which is different, both from the age to which half of the born live, and the mean age of death, is found to vary in different places and countries, from about 1 in 19 to about 1 in 70. In Stockholm, the annual mortality was but 1 in 19 (Price's Observations, vol. ii. p. 136); and in some of the villages in England, even at the time that Dr Price wrote, it was as low as 1 in 70 and 1 in 75.

Proportion of births to the population.

The proportion of births to the population appears to vary in different countries and under different circumstances, from about 1 in 17 to 1 in 49. In New Spain, according to Humboldt, it was 1 in 17. In New Jersey, according to the rate of increase determined by the census taken in 1738 and seven years afterwards, the proportion of births must have been about 1 in 18. (Price, vol. ii. p. 50.) At present, as far as can be collected from scattered facts and inferences, the proportion of births in the whole of the United States is about 1 to 19. In the table for Prussia and Lithuania given by Sussmilch, it appears, that after the great plague of 1709 and 1710, and omitting the extraordinary year immediately subsequent, the proportion of births in the five years ending with 1716 was 1 in less than 17;[5] while, according to M. Muret, in the parish of Leyzin, the proportion of births was only 1 in 49 of the population.

Variations in the number of subsisting marriages to one annual birth.

The number of subsisting marriages which yields one annual birth appears to vary from 12 to 4, and the two extreme cases occur in what may be called the same country, and are both noticed by M. Muret; the one in the parish of Leyzin, which presents all the symptoms of the prudential check to population in the greatest excess, and where twelve subsisting marriages yield only one annual birth; and the other in the parish of St Cergue, in the Jura, where marriage is encouraged by the habit of emigration, and four subsisting marriages are sufficient to yield one annual birth.

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Different proportions of the population under 16.

The proportion of the population under 16 years of age to that above 16 seems to vary in different countries and places, and under different circumstances, from one half to one fourth. In the United States, it appears by the late census that it is one half; while in the canton of Berne it is not much more than one fourth, and in the parish of Leyzin not more than one fourth.[6]

Variations in the mortality under 15.

The mortality under the age of 15 varies in different places and circumstances, from above two thirds to one fifth. It appears from a table of Dr Price, that in Stockholm above two thirds died under 15 (vol. ii. p. 418); while, according to M. Muret, the proportion of the deaths under the age of 15 was, in the whole of the Pays de Vaud, one third, in many parishes of the Alps one fourth, and in the extraordinary parish of Leyzin only one fifth.[7]

Under these very great variations in the registers of different countries and places, and in the structure of their population, it is obvious that we might fall into the grossest possible errors, by applying the registers of one country to the population of another. Even if we could find a country which was near to a just mean between these opposite extremes, and the registers of which were kept with the greatest accuracy, we could not apply such registers to any other country with a view to any important inferences, unless we knew that the two countries nearly resembled each other, not only in one or two particulars, but in all the main points relating to the structure of their population and the character of the prevailing checks to it.

First tables of mortality formed from the registers of towns.

When attention was first directed to tables of mortality with a view to assurances on lives and survivorships, these tables were almost universally formed from the registers of towns, and of the neighbouring villages influenced by them. Buffon, calculating the probability of life from the registers of three parishes in Paris, and twelve country parishes in the neighbourhood, collected by M. Dupré de St Maur, makes it appear that half of the born died under eight years of age. The parishes in Paris seemed to be healthier than the villages in the neighbourhood, which was occasioned by the custom of sending the children from the city to be nursed in the country. Other calculations from the registers of Breslau by Dr Halley, of London by Mr Simpson, and subsequently of Northampton, Warrington, Chester, Norwich, &c. by Dr Price and other writers, all concurred to convey the impression that more than half of the born die under the age of puberty; and though Dr Price, in his two volumes of Observations on Reversionary Payments, takes frequent opportunities of dwelling upon the prodigious difference in the mortality of towns and of country situations, and produces abundance of evidence to show that, taken together, in the actual state of things, half of the born live much beyond the age of puberty; yet, among some persons who have not attended to the subject, the former impression seems still to have remained; and, what is more strange, it has been lately asserted that this must happen from the constitution and course of human nature (Godwin's Answer to Malthus); which is going very much further than to say that it happens under the poverty, distress, and unhealthy occupations which are known to affect the mortality of a considerable body of people in all the nations with which we are acquainted.

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[1] This last number, stated by M. Muret for the parish of Leyzin, on the Alps, is so very extraordinary, that possibly it may not be correct.

[2] Observations on Reversionary Payments, vol. ii. p. 421, 7th edition.

[3] *Ibid.* vol. ii. p. 128.

[4] *Mémoires, &c. par la Société Economique de Berne*, 1766, table v. p. 65.

[5] *Gottliche Ordnung*, vol. i. table xxi. p. 83 of the tables. Malthus, vol. ii. p. 168, 5th edition.

[6] *Mémoires, &c. par la Société Economique de Berne*, 1766, pp. 11 and 12.

[7] *Ibid.* table xiii. p. 12.

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years of the period will only have produced half their births, and the other half ought to be added. But half the births of any eight years may be considered as nearly equal to all the births of the succeeding three years and three quarters. In instances of the most rapid increase it will rather exceed the births of the next three years and a half, and in cases of slow increase approach towards the births of the next four years. The mean, therefore, may be taken at three years and three quarters. Consequently, if we subtract the births of the first three years and three quarters, and add the births of the three years and three quarters subsequent to the period, we shall have a number of births nearly equal to the number of births produced by all the marriages included in the period, and, of course, the prolificness of marriages. But if the population of a country be increasing regularly, and the births, deaths, and marriages continue always to bear the same proportion to each other and to the whole population, it is evident that all the births of any period will bear the same proportion to all the births of any other period of the same extent taken a certain number of years later, as the births of any single year to the births of a single year taken the same number of years later. And, consequently, to estimate the prolificness of marriages, we have only to compare the marriages of the present, or any other year, or the mean of five years, with the births of a subsequent year, or the mean of five years taken three years and three quarters later.

It has been supposed, in the present instance, that each marriage yields four births; but the proportion of births to marriages apparent in the registers of most of the countries of Europe is four to one, and as the population of most of the countries of Europe is known to be increasing, the prolificness of marriages must be greater than four. If, allowing for this circumstance, we take the distance of four years instead of three years and three quarters, we shall still be sure of not erring in excess. And though undoubtedly the period which we take, whatever it may be, will not answer exactly in different countries, yet its application generally will not be so incorrect as we might at first imagine, because, in countries where the marriages are more prolific, the births generally follow at shorter intervals, and where they are less prolific, at longer intervals; and, with different degrees of prolificness, the length of the period might still remain the same.

Probably, however, the period here assumed, which is the one taken by Mr Malthus, is too short. If, as he says, there is reason to think, that, in almost all registers, the omissions in the births and deaths are greater than in the marriages, there ought to be a greater number of births to each marriage, in which case it would take a longer time to have them in; and if, further, it is probable that a birth every other year is too rapid a succession for those countries where the marriages are frequently late, it may be thought that the births at the distance of five years will more nearly represent the prolificness of marriages than at the distance of four years. But this matter must be left to the judgment of the reader.

At all events, it will follow, from what has been said, that the more rapid is the increase of population, the more will the real prolificness of marriages exceed the proportion of births to marriages in the registers.

The rule which has here been laid down attempts to estimate the prolificness of marriages, taken as they occur; but this prolificness should be carefully distinguished from the prolificness of first marriages, and of married women, and still more from the natural prolificness of women in general, taken at the most favourable age. It is probable that the natural prolificness of women is nearly the same in most parts of the world; but the prolificness of marriages is liable to be affected by a variety of circumstances peculiar to each country, and particularly by the number of second, and third, and late marriages. In all countries the second and third marriages alone form a most important consideration, and materially influence the average proportions. According to Sussmilch, in all Pomerania, from 1748 to 1756 both included, the number of persons who married were 56,956, and of these 10,586 were widows and widowers.[1] According to Busching, in Prussia and Silesia, for the year 1781, out of 29,308 persons who married, 4841 were widows and widowers;[2] and, consequently, the proportion of marriages will be given fully one sixth too much. In estimating the prolificness of married women, the number of illegitimate births would tend, though in a slight degree, to counterbalance the overplus of marriages; and as it is found that the number of widowers who marry again is greater than the number of widows, the whole of the correction should not, on this account, be applied; but in estimating the proportion of the born which lives to marry, which is what we are now about to proceed to, the whole of this correction is always necessary.

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Proportion of the born which lives to marry.

To find the proportion of the born which lives to marry, from registers, we must consider that the marriages of any year can never be contemporary with the births from which they have resulted, but must always be at such a distance from them as is equal to the average age of marriage.

If the population be increasing, the marriages of the present year have resulted from a smaller number of births than the births of the present year; and, of course, the marriages, compared with the contemporary births, will always be too few to represent the proportion of the born which lives to marry, and the contrary will take place if the population be decreasing; and to find this proportion, after having first made the proper correction for second and third marriages, we must compare the marriages of any year with the births of a previous year at the distance of the average age of marriage.[3]

Expectation of life.

The third principal object which it is desirable to attain, and of which some estimate may be formed from registers, is the expectation of life. It has before been stated, that, in a country where the births and deaths are equal, the rate of the annual mortality will express the expectation of life, or the average age of death. But if the population be increasing, the actual population of any one year will be greater than would belong to the contemporary deaths, supposing the births equal to the deaths, and less than would belong to the contemporary births, supposing the deaths equal to the births. Consequently, if we divide the actual population by the number of contemporary deaths in an increasing country, the result will be too high to express the average age of death belonging to any given number of births. If we divide the actual population by the number of births, the result will be too low to express this average, or, in other words, to express the expectation of life. And, in order to approximate to the true proportion, we are directed by Dr Price (vol. ii. p. 39, seventh edition), in the absence of better data, to divide the actual population by a mean between the proportions of deaths and births. Consequently, when we know the proportion of births to deaths in any country, and the proportions which they usually bear to the whole population, we may form some estimate of the expectation of life, or the average age of death.

If we attend to these observations in drawing our infer-

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[1] *Gottliche Ordnung*, vol. i. tables, p. 98.

[2] Malthus, vol. ii. p. 140.

[3] It is a shorter and more obvious process to compare the marriages at once with the births of the earlier period, than with the deaths, as Mr Malthus has done.

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ences from registers, we shall generally be able to form an approximating estimate of the prolificness of marriages, the proportion of the born living to marry, and the expectation of life, in different countries and places, and under different circumstances; or if we cannot do this satisfactorily, owing to the varying rate of increase, and the inaccuracy of the registers, we shall at least guard ourselves against drawing incorrect inferences from them in their present state, and reconcile many of the difficulties with which they appear to be accompanied.

Prolificness of marriages in England.

Thus, to estimate the prolificness of marriages in England, the proportion of the marriages to the births, according to the parochial returns ending with 1820, was 100 to 369; adding one sixth for the omissions in the births, or on the present occasion only one seventh, in order to make full allowance for illegitimate births, the proportion of marriages to births will be as 100 to 422. These births, at the rate at which the population was increasing in England and Wales from 1810 to 1820, would, in about four years and a half, increase ·07, which, added to 4·22, makes 4·51. Consequently, the prolificness of marriages, taken as they occur, and including second and third marriages, would be 4·51. If we wish to estimate the prolificness of married women, we must subtract from the marriages those which consist of widows who have married again. According to some tables of Sussmilch, this would be little less than one sixth, according to others one eighth. If we take one seventh, and deduct it from the marriages, the proportion will be 1 to 5·26, that is, each married woman will have 5·26 births. But of these married women, some have married at above forty-five years of age, and many more above thirty-five, so that there can be little doubt that, if the births could be collected from all the marriages in which the age of the woman did not exceed thirty-five, nor the age of the man forty-five, the births would appear to be nearly six; and this number would be still further increased if the average age of marriage for males was twenty-two, and for females twenty. These conclusions are fully confirmed by some accurate observations of M. Muret. At Vevay, where the proportion of marriages to births, in the registers, was as ten to thirty-nine, he found that 375 mothers had had 2093 children born alive, by which it appears that each mother had produced 5·55 births. But these, M. Muret observes, were all mothers, which is not the case of all married women. Allowing, however, for the usual proportion of barren wives at Vevay, which was about twenty out of 478, it appears that the married women, one with another, must have had above 5·3 births. Yet this was in a town where he intimates that the inhabitants do not enter into the marriage state at the time when nature calls them, nor, when married, always have as many children as they might have. It is evident, therefore, that the proportions of marriages to births, to be found in registers, require considerable and important corrections, in order to deduce from them just estimates of the prolificness of marriages, the prolificness of married women, and the prolificness of women marrying at the most favourable age. The instance here given is sufficient to illustrate the mode in which the rule should be applied.

Proportion of the born living to marry in England.

If we wish to apply the rule for estimating the proportion of the born living to marry in England, we must first take the proportion of marriages to births in the registers. This proportion, as before stated, was, during the ten years ending with 1820, as 100 to 369; which, increased by one sixth, the supposed omissions in the registers of births will be as 100 to 430. But the marriages of the present year must have resulted, not from the births of the present year, but from the births at such an earlier period in the registers as is equal to the average age of marriage. Suppose this age to be twenty-eight, then, at the rate at which the population was increasing, the present marriages must have resulted from a number of births equal to about two thirds of the present number, so as to be to the present marriages in the proportion of 286 instead of 430 to 100. But of the 200 persons forming the 100 marriages, more than one sixth have been married before. Deducting, therefore, one sixth from the marriages, the proportion of the marriages to the births from which they have resulted will be as 100 to 343; or, out of 343 births, 200 have lived to be married once or oftener; from which it would appear, that on account of the late increase in the healthiness of the country, a greater proportion had lived to marry than when Mr Malthus last estimated it; which, together with a slight increase in the prolificness of marriages apparent in the latter registers, may account for the more rapid increase of the population from 1810 to 1820. It should be recollected, however, that as the rate of increase which prevailed from 1810 to 1820 had by no means prevailed during the whole twenty-eight years, the births, from which 200 person had lived to marry in 1820, were decidedly more than 343.

It will be observed how very important the correction for second and third marriages is. Supposing each marriage to yield four births, and the births and deaths to be equal, it might at first be thought necessary, that in order to keep up the population, half of the born should live to marry; but if, on account of the second and third marriages, we subtract one sixth from the marriages, and then compare them with the births, the proportion will be as five to twenty-four; and it will appear, that instead of one half, it will only be necessary, that out of twenty-four births, ten should live to marry. Upon the same principle, if the births were to the marriages as four to one, and exactly half of the born lived to marry, it might be supposed at first that the population would be stationary; but if we subtract one sixth from the marriages, and then compare them with the births, it will be obvious that, on the supposition of half the born living to marry, the births at the earlier period in the registers, at the distance of the age of marriage, must be to the present births as five to six, which would imply a moderate rate of increase.

To estimate the proportion of male births living to marry, we must subtract full one fifth from the marriages; and, according to this correction, if each marriage yielded four births, it would only be necessary that two male children out of five should live to marry, in order to keep up the population. It is necessary, also, in estimating the proportion of male births living to marry, to make allowance for the greater number of males born.

The foregoing illustrations and remarks show the error of supposing that a country must be in a precarious state when the proportion of births to marriages in the registers is less than four to one. If, indeed, this observation were just, the population of many countries in Europe would be in a precarious state, as in many countries the proportion is less than this. But it has been shown in what manner this proportion in the registers should be corrected, in order to make it a just representation of the prolificness of marriages; and if a large part of the born live to marry, and the age of marriage be considerably earlier than the expectation of life, such a proportion in the registers is by no means inconsistent with a rapid increase of population.

In Russia, the proportion of births to marriages is less than four to one; yet, on account of the large proportion of the born living to marry, the early age of marriage, and the high expectation of life, it is one of the countries in Europe which increases the fastest. In England, the population increases much more rapidly than in France; yet in England the proportion of births to marriages in the registers, when allowance has been made for omissions, was, from 1800 to 1810, four to one, while in France it was four and four fifths to one. (Malthus, vol. ii. p. 161. 5th edit.)

In England, indeed, for the ten years from 1810 to 1821,

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the proportion of births to marriages seems slightly to have exceeded the former proportion, being about 4·22 to 1; but this excess has been accompanied by such a rapidity of increase as would double the population in less than forty-six years; and comparing this rapid rate of increase with the slow increase of France, where the births were to the marriages as four and four fifths to one, and in Sweden, where these proportions were as four and one fourth to one, it follows that the two other causes of the excess of births above the deaths, besides the prolificness of marriages, must have very great power, and that the proportion of births to marriages, as found in registers, when taken alone, is a most uncertain criterion of increase.

Expectation of life in England.

To apply the rule for estimating the average age of death, or the expectation of life, in England, we must first ascertain from the registers the proportions which the births and deaths bear to the whole population. The annual average of the births for the ten years from 1810 to 1821 was 325,506, of the deaths 200,999. Adding one sixth to the births, and one twelfth to the deaths, for the omission in the registers, the births will be 379,757, and the deaths 217,749. The population of England and Wales, according to the census taken in 1810, was 10,502,500, in 1821, 12,218,500,[1] the mean of which is 11,360,500. The average births and deaths, compared with the mean population, give $\frac{1}{29{\cdot}9}$ as the proportion of the births, and $\frac{1}{52{\cdot}17}$ as the proportion of the deaths; and, according to Dr Price, the mean between them, which in this case is forty-one, will give the expectation of life. This rule, however, is only a rough approximation, and, in the few cases where sufficient data have been obtained in progressive countries for calculating the expectation of life more accurately, it has turned out to be much nearer to the annual mortality than to the mean here referred to; while, according to the more correct estimates before adverted to, the annual mortality might, with the same expectation of life, be in different countries 1 in 39·38, 1 in 41·97, or 1 in 41·09, according as the population was stationary, or progressive at various rates.

This appears in the table which Dr Price himself calculated for Sweden (vol. ii. p. 410, 7th edit.), founded on data which he considered as quite satisfactory. It also appears in the table for Sweden and Finland, subsequently calculated by Mr Milne from similar data, in his Treatise on Annuities and Assurances, vol. ii. p. 569; and, further, in a table for Sweden and Finland, published in this work, under the head MORTALITY. We have also seen a calculation by Mr Milne, by which it appears that the difference between the annual mortality and the expectation of life goes on increasing with the rate of the increase of the population to a certain point, but afterwards, owing to the increasing proportion of young children included in the population, diminishes; and is less when the population doubles in twenty-five years, than when it doubles in fifty years. Thus, on the three different suppositions of a stationary population, a population doubling in fifty years, and a population doubling in twenty-five years (all subjected to the same law of mortality as that which prevailed in Sweden and Finland during the five years ended with 1805), in the first case, both the expectation of life and the annual mortality would be 39·388, and, of course, the expectation of life would be the same in all the cases; but in the second case, the annual mortality would be 1 in 41·971; and, in the third, 1 in 41·096. It would be difficult, however, or at least premature, without further data, to lay down a general rule, with a view to determine correctly the expectation of life at birth, in countries progressive at various rates. But, from what has been stated, it may safely be concluded, that the expectation of life lies very much nearer the annual mortality, particularly in cases of very rapid increase, than to the mean proposed by Dr Price; and that both the expectation of life, and the age to which half of the born live, are, in most countries, and especially in England, at the present time, considerably higher than they have generally been estimated.

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It may be remarked here, in reference to England during the ten years from 1810 to 1821, that the omissions assumed in the births and deaths do not give such proportions as to make the increase of population, from the excess of births above the deaths, answer to the increase determined by the two censuses; an agreement which must necessarily take place if both the enumerations and the registers are accurate, and no external causes disturb the result. An addition of one sixth to the births, and one twelfth to the deaths, seemed to answer correctly for the interval from 1800 to 1810; but to produce the same coincidence under the more rapid increase of the subsequent ten years, either a greater allowance must be made for omissions in the births, or a less allowance for the omissions in the deaths. If we add one fifth instead of one sixth to the births, retaining one twelfth for the deaths, the excess of births above deaths in the ten years will be 1,728,587, the excess according to the censuses being 1,716,000; if we add only one thirtieth to the deaths, retaining one sixth for the births, the excess will be 1,720,502, within 4502 of the excess, as shown by the censuses; whereas, under the actual allowances which have been made for omissions, the excess will be only 1,620,800, leaving a difference of 95,200, and on the wrong side. On account of the almost incredible healthiness, considering our great towns and manufactories, which would be implied by supposing the deaths to be only deficient one thirtieth, an increased omission in the births might be thought more probable; but it is believed, that since 1812 the omissions in the births have been diminished rather than increased; and under this uncertainty it has been thought better to leave the question as it stands at present, rather than attempt to determine it on insufficient data. It should always be remembered, however, that if the increase of population by the enumerations is different from the increase of population by the registers, one or the other must be incorrect.

Expectation of life at birth, and annual mortality, not the same when the population is progressive.

On the supposition that the omissions in the deaths were only one thirtieth, the average mortality, compared with the average population, would be 1 in 54·7; and the proportion of births, with the addition of one sixth, being, as before stated, 1 in 29·9, the expectation of life, according to Dr Price's rule, would be 42·3. On the other supposition, of an omission of one fifth of the births and one twelfth of the deaths, the births would be 1 in 29, and the deaths 1 in 52·17, and the expectation of life would be 40·58.

It appears, then, that when the population of a country is progressive, it would be erroneous to estimate its healthiness by the proportion which the annual mortality bears to the whole population. Healthiness must be measured by the expectation of life; and if, with the same expectation of life, the annual mortality is affected by the rate of increase, it is obvious that the healthiness of different countries may be different, with the same rate of annual mortality.

Mortuary registers fallacious.

But whilst it is evidently necessary that we should be cautious in inferring that a country is healthy just in proportion to the smallness of its annual mortality, we should be still more cautious in inferring that it is unhealthy at all the ages under puberty, on account of the number which

[1] Preliminary Observations to Population Abstracts, p. 32.

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appear to die in mortuary registers under that age. Here, as in the preceding case, but in a much greater degree, the excess of the births above the deaths has a powerful effect, but exactly in the opposite direction. When we compare the annual mortality of an increasing country with its actual population, we compare with it a number of deaths which may be said, properly speaking, to belong to an earlier and smaller number of births, and must necessarily represent the country as more healthy than it really is. On the other hand, when, in a mortuary register, we compare the deaths under puberty with those above, if the population be increasing, we evidently compare the deaths belonging to a much greater number of births than those which have furnished the deaths above the age of puberty; and, consequently, these proportions must represent the country as much less healthy than it really is.[1] According to the mortuary registers of Sweden for twenty-one years from 1755 to 1776, more than half of the deaths were under fifteen, but it was by no means true that half of the born died under fifteen.[2] In the tables of mortality for Sweden during the same period, constructed by Dr Price, it appears that half of the born lived to above thirty-three years.[3]

In the same manner, in drawing inferences from an abstract of the mortuary registers of the principal cities in America, Baltimore, Boston, New York, and Philadelphia, given by Dr Seybert,[4] we must take care not to conclude that the proportions of the deaths which take place under twenty years of age represent the proportions of any given number of births in these cities which die under twenty. As, on account of the excess of the births above the deaths, all the early ages of the population are more numerous in proportion than the other, there will necessarily be a greater proportion of the deaths at these ages than would naturally belong to a given number of births, if each infant born were traced to the age of its death.

In the present case, the abstract is only for a year, and no safe conclusions therefore can be drawn from it; but, so far as it goes, as even, notwithstanding the increase of population, these mortuary registers show that considerably less than half of the deaths take place under twenty (on an average only about 45½ per cent.), it would appear, that in the early ages of life, even the towns of America are more healthy than the whole of Sweden from 1755 to 1776. It should, however, be considered, that though the towns in America may be increasing fast by procreation, they are increasing still faster by the influx of inhabitants from the country; and as these inhabitants generally come to the towns after the age of sixteen, this accession diminishes the proportion of persons in the earlier ages of life so much, that there is probably a larger proportion of mortality at these ages in the country than in the towns.

Criterion of the prevalence of prudential restraint.

One of the most interesting and useful points of view in which registers can be considered, is in the proofs which they afford of the varying prevalence of the prudential check to marriage and population in different countries and places. It has been not an uncommon opinion, and has even been strongly expressed of late years, although the subject has been much better understood than formerly, that the labouring classes of people, under the circumstances in which they are placed, cannot reasonably be expected to attend to prudential considerations in entering upon the marriage state. But that this opinion does them great injustice, is not only obvious to common observation, by which we can scarcely fail to see that numbers delay marriage beyond the period when the passions most strongly prompt to it, but is proved by the registers of different countries, which clearly show, either that a considerable number of persons of a marriageable age never marry, or that they marry comparatively late, and that their marriages are consequently less prolific than if they had married earlier. As the prudential restraint on marriage may show itself in either of these ways, it may prevail nearly in the same degree with a different proportion of the whole population. But on the supposition of the same natural prolificness in the women of most countries, the smallness of the proportion of births will generally indicate, with tolerable correctness, the degree in which the prudential check to population prevails, whether arising principally from late, and consequently unprolific marriages, or from a large proportion of the population dying unmarried.

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Referring, then, to the different proportions of births in different countries as the best criterion of the different degrees in which the prudential restraint on marriage operates, it will be recollected that these proportions vary from about one in thirty-six to about one in nineteen or even seventeen, in different countries, and in a much greater degree in different parishes or districts.

A particular parish in the Alps has already been mentioned, where the births were only a forty-ninth part of the population; and it appears by the late returns of the parish registers of England and Wales, that the births in the county of Monmouth are only one in forty-seven, and in Brecon one in fifty-three;[5] which, after making ample allowance for omissions, would show the prevalence of the prudential restraint on marriage in a high degree.

Effect of the absence of prudential restraint.

If in any country all were to marry at twenty or twenty-one, the proportion of the births would probably be more than one in nineteen; and this result would be still more certain if the resources of the country could not support an accelerated rate of increase, than if the means of subsistence were in the greatest abundance, and the demand for labour as effectual as it has ever been in the United States. Of the latter supposition, taking the births at one nineteenth, and the expectation of life the same as it is in England, the effect would be to occasion a most rapid increase of population; and the period of doubling, instead of being about forty-six or forty-eight years, would be less than in America. On the other hand, if the resources of the country could not support a more rapid increase than that which has taken place in England and Wales during the ten years previous to the census of 1821, the effect would be a great diminution in the expectation of life. If the births were one in nineteen instead of one in nearly thirty, the same rate of increase would take place as at present if the annual mortality were increased to about one in twenty-six and a half; and in that case the expectation of life would be reduced in the proportion of from forty-one, or, as is more probable, from above forty-five, to less than twenty-six.[6] This is the kind of effect which must inevitably follow the absence of the prudential check to marriage and population; and it cannot be doubted, that a considerable part of the premature mortality which is found to take place in all parts of the world is occasioned by it. The laws of nature, in application to man as a reasonable being, show no tendency to destroy half of the human race under the age of puberty. This is only done in very particular situations, or when the

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[1] In the first case, the effect is, in a considerable degree, counteracted by the large proportion of children under four years old, which a rapid increase occasions. In the second case, the effect has no such drawback.

[2] Price's Observations, vol. ii. p. 405, 7th edit.

[3] *Ibid.* table xlv. vol. ii. p. 413.

[4] Statistical Annals, p. 48.

[5] Preliminary Observations, p. 27.

[6] If, as it has appeared, the expectation of life, though by no means the same, does not differ very much from the annual mortality, and the annual mortality in this country during the ten years from 1810 to 1820, after every abatement, appears to be not more than one in fifty-one, the expectation of life cannot be less than forty-five, and is probably greater.

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constant admonitions which these laws give to mankind are obstinately neglected.

Objection to the principle of population arising from the mortality it must occasion.

It has been said that a tendency in mankind to increase at such a rate as would double the population in twenty-five years, and, if it had full scope, would fill the habitable globe with people in a comparatively short period, cannot be the law of nature, as the very different rate of increase which is actually found to take place must imply such an excessive degree of mortality and destruction of life as to be quite irreconcileable with actual facts and appearances. But the peculiar advantage of a law of increase in a geometrical progression is, that though its power be absolutely immense if it be left unchecked, yet, when this becomes impossible, it may be restrained by a comparatively moderate force. It can never of course happen that any considerable part of that prodigious increase which might be produced by an uninterrupted geometrical progression, should exist, and then be destroyed. The laws of nature, which make food necessary to the life of man, as well as of plants and animals, prevent the continued existence of an excess which cannot be supported, and thus either discourage the production of such an excess, or destroy it in the bud, in such a way as to make it scarcely perceptible to a careless observer. It has been seen, that in some countries of Europe where the actual progress of the population is slower than in many others, as in Switzerland and Norway, for instance, the mortality is considerably less. Here, then, the necessity of a greater check to the natural progress of population produces no increase of mortality. And it appears farther, that even the degree of mortality which in each year would be sufficient to destroy that excess of births which would naturally be produced if all married young, and all could be supported, might take place, and often does take place in particular situations, and yet is very little noticed. About the middle of last century, the mortality in Stockholm and London was about one in nineteen and one in twenty. This is a degree of mortality which would probably keep the births on a level with the deaths, even though all married at twenty. And yet numbers resorted both to Stockholm and London from choice, the greater part probably not aware that, by so doing, they would shorten their own lives and those of their children; and the rest thinking that the difference was not worth attending to, or was at least balanced by the advantages of society and employment which the town presented. There is nothing, therefore, in the actual state of the mortality observed to take place in different countries and situations, which, in the slightest degree, contradicts the supposition of a natural tendency to increase quite as great as that which has been stated.

Objection that mere tendencies are not to be considered.

It has been further remarked, that as, in point of fact, it very rarely happens that mankind continue to increase in a geometrical progression of any kind, and only in a single instance in such a one as to double the population in twenty-five years, it is useless and absurd to lay any stress upon tendencies which never for any length of time together produce their natural effects. But it might really as well be said, that we are not to estimate the natural rate of increase in wheat or sheep, as it is quite certain that their natural tendency to increase has never practically continued to develope itself for so long a time together as that of mankind. Both as a physical and even economical question, it is curious and desirable to know the natural law of increase which prevails among the most important plants and animals. In the same view, it must be still more interesting to know the natural law of increase with respect to man. It may be said, indeed, with truth, that the actual appearances all around us,—the varying rate of increase in different countries, its very slow progress or stationary state in some, and its very rapid progress in others,—must be a mass of anomalies, and quite contrary to the analogies of all the rest of animated nature; if the natural tendency of mankind to increase be not at the least as great as that which is developed under the most favourable circumstances, while in all others it is kept down by the varying difficulties which the state of the soil and other obstacles oppose to it. But the question, as it applies to man, assumes at once a tenfold importance, in reference to the moral and political effects which must result from those checks to increase, the existence and operation of which, in some form or other, no human exertions can by possibility prevent. A field is here opened for the most interesting inquiries which can engage the friends of human happiness.

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But, as a preliminary to these inquiries, it is obvious that we must know the degree of force to be overcome, and the varying character of the checks which, in the different countries of the world, are practically found to overcome it; and, for this purpose, the first step must be an endeavour to ascertain the natural law of population, or the rate at which mankind would increase under the fewest known obstacles. Nor can this tendency to increase ever safely be lost sight of in the subsequent inquiries, which have for their object the improvement of the moral condition of man in society.

Right of the poor to full support considered.

The existence of a tendency in mankind to increase, if unchecked, beyond the possibility of an adequate supply of food in a limited territory, must at once determine the question as to the natural right of the poor to full support in a state of society where the law of property is recognised. The question, therefore, resolves itself chiefly into a question relating to the necessity of those laws which establish and protect private property. It has been usual to consider the right of the strongest as the law of nature among mankind as well as among brutes; yet, in so doing, we at once give up the peculiar and distinctive superiority of man as a reasonable being, and class him with the beasts of the field. In the same language, it may be said that the cultivation of the earth is not natural to man. It certainly is not to man, considered merely as an animal without reason. But to a reasonable being, able to look forward to consequences, the laws of nature dictate the cultivation of the earth, both as the means of affording better support to the individual, and of increasing the supplies required for increasing numbers; the dictates of those laws of nature being thus evidently calculated to promote the general good, and increase the mass of human happiness. It is precisely in the same way, and in order to attain the same object, that the laws of nature dictate to man the establishment of property and the absolute necessity of some power in the society capable of protecting it. So strongly have the laws of nature spoken this language to mankind, and so fully has the force of it been felt, that nothing seems to be thought so absolutely intolerable to reasonable beings as the prevalence in the same society of the right of the strongest; and the history of all ages shows, that if men see no other way of putting an end to it, than by establishing arbitrary power in an individual, there is scarcely any degree of tyranny, oppression, and cruelty, which they will not submit to from some single person and his satellites, rather than be at the mercy of the first stronger man who may wish to possess himself of the fruit of their labour. The consequence of this universal and deeply-seated feeling, inevitably produced by the laws of nature, as applied to reasonable beings, is, that the almost certain consequence of anarchy is despotism.

Allowing, then, distinctly, that the right of property is the creature of positive law, yet this law is so early and so imperiously forced on the attention of mankind, that if it cannot be called a natural law, it must be considered as the most natural as well as the most necessary of all posi-

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tive laws; and the foundation of this pre-eminence is its obvious tendency to promote the general good, and the obvious tendency of the absence of it to degrade mankind to the rank of brutes.

As property is the result of positive law, and the ground on which the law which establishes it rests is the promotion of the public good and the increase of human happiness, it follows, that it may be modified by the same authority by which it was enacted, with a view to the more complete attainment of the objects which it has in view. It may be said, indeed, that every tax for the use of the government, and every country or parish rate, is a modification of this kind. But there is no modification of the law of property having still for its object the increase of human happiness, which must not be defeated by the concession of a right of full support to all that might be born. It may be safely said, therefore, that the concession of such a right, and a right of property, are absolutely incompatible, and cannot exist together.

To what extent assistance may be given even by law to the poorer classes of society when in distress, without defeating the great object of the law of property, is essentially a different question. It depends mainly upon the feelings and habits of the labouring classes of society, and can only be determined by experience. If it be generally considered as so discreditable to receive parochial relief, that great exertions are made to avoid it, and few or none marry with a certain prospect of being obliged to have recourse to it, there is no doubt that those who were really in distress might be adequately assisted, with little danger of a constantly increasing proportion of paupers; and in that case a great good would be attained, without any proportionate evil to counterbalance it. But if, from the numbers of the dependent poor, the discredit of receiving relief is so diminished as to be practically disregarded, so that many marry with the almost certain prospect of becoming paupers, and the proportion of their numbers to the whole population is in consequence continually increasing, it is certain that the partial good attained must be much more than counterbalanced by the general deterioration in the condition of the great mass of the society, and the prospect of its daily growing worse; so that, though, from the inadequate relief which is in many cases granted, the manner in which it is conceded, and other counteracting causes, the operation of poor-laws such as they exist in England might be very different from the effects of a full concession of the right, and a complete fulfilment of the duties resulting from it, yet such a state of things ought to give the most serious alarm to every friend to the happiness of society, and every effort consistent with justice and humanity ought to be made to remedy it. But whatever steps may be taken on this subject, it will be allowed, that with any prospect of legislating for the poor with success, it is necessary to be fully aware of the natural tendency of the labouring classes of society to increase beyond the demand for their labour, or the means of their adequate support, and of the effect of this tendency to throw the greatest difficulties in the way of permanently improving their condition.

It would lead far beyond the limits which must be prescribed to this article, to notice all the various objections which have been made by different writers to the principles which have been here explained. Those which contain in them the slightest degree of plausibility have been answered by Mr Malthus in various parts of the late editions of his work, and particularly in the appendix to the fifth edition, to which we refer the reader. We will only, therefore, further notice the objection which has been made by some persons on religious grounds; for, as it is certainly of great importance that the answer which has been given to it should be kept in mind, we cannot refuse a place to a condensed statement of it at the end of this article.

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Religious objection considered.

It has been thought that a tendency in mankind to increase beyond the greatest possible increase of food which could be produced in a limited space, impeaches the goodness of the Deity, and is inconsistent with the letter and spirit of the Scriptures. If this objection were well founded, it would certainly be the most serious one which has been brought forward; but the answer to it appears to be quite satisfactory, and it may be compressed into a very small compass.

First, It appears that the evils arising from the principle of population are exactly of the same kind as the evils arising from the excessive or irregular gratification of the human passions in general, and may equally be avoided by moral restraint. Consequently, there can be no more reason to conclude, from the existence of these evils, that the principle of increase is too strong, than to conclude, from the existence of the vices arising from the human passions, that these passions are all too strong, and require diminution or extinction, instead of regulation and direction.

Secondly, It is almost universally acknowledged, that both the letter and spirit of revelation represent this world as a state of moral discipline and probation. But a state of moral discipline and probation cannot be a state of unmixed happiness, as it necessarily implies difficulties to be overcome, and temptations to be resisted. Now, in the whole range of the laws of nature, not one can be pointed out which so especially accords with this scriptural view of the state of man on earth; as it gives rise to a greater variety of situations and exertions than any other, and marks, in a more general and stronger manner, and nationally as well as individually, the different effects of virtue and vice, of the proper government of the passions, and the culpable indulgence of them. It follows, then, that the principle of population, instead of being inconsistent with Revelation, must be considered as affording strong additional proofs of its truth.

Lastly, It will be acknowledged, that in a state of probation, those laws seem best to accord with the views of a benevolent Creator, which, while they furnish the difficulties and temptations which form the essence of such a state, are of such a nature as to reward those who overcome them with happiness in this life as well as in the next. But the law of population answers particularly to this description. Each individual has the power of avoiding the evil consequences to himself and society resulting from it, by the practice of a virtue dictated to him by the light of nature, and sanctioned by revealed religion. And as there can be no question that this virtue tends greatly to improve the condition and increase the comforts both of the individuals who practise it, and through them of the whole society, the ways of God to man with regard to this great law are completely vindicated.

Subjoined are two tables, which may assist the reader in calculating the rate of increase in different countries, under different circumstances, and from different data. The first is the table calculated by Euler, and printed in Mr Malthus's work, at the end of his chapter on the Fruitfulness of Marriage; and the second has been calculated by Mr Bridge of Cambridge, well known as an able mathematician, and most useful elementary writer.

The first is to be used when it is wished to estimate the rate of increase by the proportions of the births to the deaths, and of these to the whole population. The yearly increase of people, independently of immigration, is the yearly excess of the births above the deaths; and the yearly rate of increase is measured by the proportion which this excess bears to the whole population. The fraction expressing the deaths must therefore be subtracted from the fraction expressing the births, and the remainder will be the fraction expressing the yearly rate of increase; opposite to which will be found the number of years in which

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The second table is to be used when it is wished to know the period of doubling, resulting from a given per centage increase in ten years, determined by enumeration. An estimate of population from births and deaths is always liable to much uncertainty, on account of the varying proportions which they bear to the population. The only remedy for this uncertainty is a census; and as the useful custom of taking a census of the population every ten years has latterly prevailed in some countries, the second table is constructed to show the period of doubling, or general rate of increase, which results from any given per centage increase in ten years. The first column represents the per centage increase in ten years determined by two enumerations; and the second column the number of years in which the population will double itself, supposing it to proceed at the same rate. (Y. Y. Y. Y.) Population.

TABLE I.

The Proportion of the Excess of Births above the Deaths to the whole of the Living.	Periods of Doubling in Years and Ten Thousandth Parts.	The Proportion of the Excess of Births above the Deaths to the whole of the Living.	Periods of Doubling in Years and Ten Thousandth Parts.
1: 10	7·2722	1: 110	76·5923
11	7·9659	120	83·5230
12	8·6595	130	90·4554
13	9·3530	140	97·3868
14	10·0465	150	104·3183
15	10·7400	160	111·2598
16	11·4333	170	118·1813
17	12·1266	180	125·1128
18	12·8200	190	132·0443
19	13·5133	200	138·9757
20	14·2066		
1: 21	14·9000	1: 210	145·9072
22	15·5932	220	152·8387
23	16·2864	230	159·7702
24	16·9797	240	166·7017
25	17·6729	250	173·6332
26	18·3662	260	180·5647
27	19·0594	270	187·4961
28	19·7527	280	194·4275
29	20·4458	290	201·3590
30	21·1391	300	208·2905
1: 32	22·5255	1: 310	215·2220
34	23·9119	320	222·1535
36	25·2983	330	229·0850
38	26·6847	340	236·0164
40	28·0711	350	242·9479
42	29·4574	360	249·8794
44	30·8438	370	256·8109
46	32·2302	380	263·7425
48	33·6161	390	270·6740
50	35·0029	400	277·6055
1: 55	38·4687	1: 410	284·5370
60	41·9345	420	291·4685
65	45·4003	430	298·4000
70	48·8661	440	305·3314
75	52·3318	450	312·2629
80	55·7977	460	319·1943
85	59·2634	470	326·1258
90	62·7292	480	333·0573
95	66·1950	490	339·9888
100	69·6607	500	346·9202
		1: 1000	693·49

TABLE II.

Per Centage Increase in Ten Years.	Period of Doubling.	Per Centage Increase in Ten Years.	Period of Doubling.
	Years.		Years.
1·	696·60	23·5	32·83
1·5	465·55	24·	32·22
2·	350·02	24·5	31·63
2·5	280·70	25·	31·06
3·	234·49	25·5	30·51
3·5	201·48	26·	29·99
4·	176·73	26·5	29·48
4·5	157·47	27·	28·99
5·	142·06	27·5	28·53
5·5	129·46	28·	28·07
6·	118·95	28·5	27·65
6·5	110·06	29·	27·22
7·	102·44	29·5	26·81
7·5	95·84	30·	26·41
8·	90·06		
8·5	84·96	30·5	26·03
9·	80·43	31·	25·67
9·5	76·37	31·5	25·31
10·	72·72	32·	24·96
		32·5	24·63
10·5	69·42	33·	24·30
11·	66·41	33·5	23·99
11·5	63·67	34·	23·68
12·	61·12	34·5	23·38
12·5	58·06	35·	23·09
13·	56·71	35·5	22·81
13·5	54·73	36·	22·54
14·	52·90	36·5	22·27
14·5	51·19	37·	22·01
15·	49·59	37·5	21·76
15·5	48·10	38·	21·52
16·	46·70	38·5	21·28
16·5	45·38	39·	21·04
17·	44·14	39·5	20·82
17·5	42·98	40·	20·61
18·	41·87		
18·5	40·83	41·	20·17
19·	39·84	42·	19·76
19·5	38·91	43·	19·37
20·	38·01	44·	19·00
		45·	18·65
20·5	37·17	46·	18·31
21·	36·36	47·	17·99
21·5	35·59	48·	17·68
22·	34·85	49·	17·38
22·5	34·15	50·	17·06
23·	33·48		

For the population of the British Islands, see the articles ENGLAND, SCOTLAND, and IRELAND.

PORCELAIN.

Porcelain. PORCELAIN, in its more general signification, comprehends all kinds of earthen ware, which are white, semitransparent, and have some degree of a vitreous texture. Hence, in this extensive meaning of the term, it includes all kinds of pottery, stoneware, delft ware, &c. But in a more limited sense, the word *Porcelain* is employed to denote only the finer kinds of earthen ware; and because this kind of ware has been, from time immemorial, manufactured in the greatest degree of perfection in China, it has obtained the name of *Chinese Porcelain*, or *China Ware*.

Derivation of the name. In the Chinese language, porcelain is denoted by the word *tse-ki*, so that the derivation of the term is not to be sought for in that language; and hence it is supposed to be of European extraction, and to be derived from the Portuguese, in which language the word *porcellano* signifies a cup or vessel.

Porcelain first brought from Japan and China. The first porcelain which was seen in Europe was brought from Japan and China. Its whiteness, transparency, and fineness of texture, with its elegance and beautiful colours, soon introduced it as an ornament of the tables of the rich and powerful, whilst, at the same time, it excited the admiration and industry of the European manufacturer. Attempts were accordingly made to imitate this kind of ware, in different countries of Europe. The first European porcelains were made in Saxony. The manufacture was afterwards introduced into France, and successively into England, Germany, and Italy, where it has arrived at various degrees of perfection, according to the nature of the materials which can be obtained, and the industry and ingenuity of the artist who superintends and directs it. But after all, to whatever degree of perfection the manufacture of this ware has attained in Europe, it must still yield, in excellence and perfection, to the porcelain of eastern countries.

Antiquity of the Chinese manufacture. Of the antiquity of the manufacture of porcelain in China, little precise information can be expected from a people who have always shown themselves so extremely averse to the freedom of intercourse with other nations. But it is said that the village or town of King-te-ching has furnished the emperors of China with porcelain since the year 442 of the Christian era; and that it is an object of so much attention to the Chinese government, that the manufacture is carried on under the superintendence of one or two mandarins sent from court.

1. *History of the Manufacture of Porcelain in China.*

The fullest account which has as yet been received in Europe of the manufacture of Chinese porcelain, has been given by Father D'Entrecolles, a Catholic missionary, who lived for some time in the village or town where the principal manufactory was established. The account which has been given by the Jesuit of this village, and of the manufacture of porcelain, is extremely interesting.

This village or town, which is celebrated as producing the best porcelain of China, is in the province of Kiang-si, and is said to be a league and a half in length, containing not less than 1,000,000 of inhabitants. Other manufactories, indeed, have been established in different parts of the Chinese empire, and particularly in those places which are convenient for the European trade, as in the provinces of Fo-kien and Canton; but the porcelain produced at these is said to be held in inferior estimation. A Chinese emperor wishing to have a manufacture of porcelain under his own inspection at Pekin, ordered workmen to be collected for the purpose, with all the necessary materials and implements; but after erecting furnaces and other expensive operations, the attempt failed, so that, in the time of D'Entrecolles, King-te-tching continued to be the most celebrated place in China for beautiful porcelain; and from this it was transported to all parts of the world. Porcelain.

Materials employed in its composition. The chief ingredients which enter into the composition of fine porcelain are petuntse and kaolin, two kinds of earth from the mixture of which the paste is obtained. The petuntse is of a pure white, and, when fully prepared, is in the form of an impalpable powder, so that it is very fine to the touch. The kaolin, he observes, is intermixed with small shining particles. These materials are carried to the manufactory in the shape of bricks. The petuntse originally consists of the fragments of rock dug out from certain quarries, and reduced to powder; and the colour of the stone which answers the purpose best, according to the Chinese, inclines somewhat to green. The fragments of rock are broken to pieces with a large iron club; they are then put into mortars, and by means of levers headed with hard stone, strongly secured with iron, they are reduced to the state of fine powder. The levers, it is scarcely necessary to observe, are moved either by the labour of men, or by water. The powder, which is afterwards collected, is then thrown into a large vessel full of water, which is strongly agitated with an iron shovel. When this mixture has been allowed to settle for some time, a substance resembling cream rises to the top, which is skimmed off, and poured into another vessel also filled with water. The water in the first vessel is again agitated, and the frothy substance which rises to the surface is collected as before, and the same operation is repeated till it appear that nothing remains but a coarse sediment which falls to the bottom by its own weight. This sediment is then carefully collected, and again subjected to the process of pulverization.

The fluid in the second vessel is allowed to remain at rest till a sediment is produced, forming a kind of crust at the bottom; and when the water above seems to be quite transparent, it is poured off by gently inclining the vessel, that the sediment may not be disturbed. The paste is then put into large moulds, and allowed to dry slowly; but before it becomes quite hard, it is divided into small square cakes, which are sold by the hundred. This is the substance which is called by the Chinese *petuntse*, and the name is said to be derived from the colour and form of this paste.

The kaolin, the other substance which is employed in the fabrication of porcelain, requires fewer operations in its preparation than the former, as it is found in nature in a state almost ready for the manufacturer. Of this substance it is said, that there are extensive mines in certain mountains, the external strata of which are composed of a kind of red earth. The kaolin is found in these mines in small lumps, and it is formed into bricks by being subjected to a similar process with the petuntse.

Nature of the finer porcelain. The fine porcelain, it has been observed, derives its fabric and texture from the kaolin. It is to this that the qualities which it possesses of resisting the most powerful heat is owing; whilst its strength and consistency is obtained by fusion with the petuntse, which enables it to resist the action of the more powerful agents. D'Entrecolles relates an anecdote which he received from a rich Chinese merchant, that the English and Dutch having purchased a quantity of petuntse, conveyed it to Europe for the purpose of manu-

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facturing porcelain; but having procured none of the kaolin, the attempt failed. They wanted, added the Chinese with a smile, to form a body, the flesh of which would support itself without bones.

Substitute for kaolin.

It is said that the Chinese have latterly discovered a new substance which may be employed in the composition of porcelain. This stone is called *hoa-chè*, the first part of the word signifying glutinous, because it is of a saponaceous quality. Porcelain made with this substance is very rare, and bears a much higher price than any other. The grain is extremely fine, and the painting with which it is ornamented, when compared with that of common porcelain, appears to exceed it as much as vellum surpasses paper. This variety of porcelain, it is added, is also remarkable for its lightness. It is besides much more brittle, and it is found very difficult to hit upon the proper degree of heat for tempering it. This substance, we are farther informed, is but rarely employed in the fabrication of the body of the porcelain; the reason of which perhaps is, the scarcity and high price of this precious article, in consequence of which the workman is contented with making it into a fine size, into which the vessel is immersed when it is dry, that it may receive a coat before it is painted and glazed; and by this process he finds that he can commmunicate to the ware a very high degree of beauty. The previous processes employed in the preparation of this substance are similar to those which are followed in the preparation of kaolin. When hoa-chè is extracted from the mine, it is washed in rain or river water, for the purpose of separating a yellowish earth with which it is contaminated. It is then reduced to powder, thrown into a vessel filled with water, and then formed into cakes. The hoa-chè prepared in this manner, without the addition of any other earth, is said to be alone sufficient in the fabrication of porcelain. It is employed, as has already been noticed, as a substitute for kaolin; but, on account of its scarcity, it is much dearer. The price of the former is three times that of the latter, and from this circumstance the value of porcelain made with hoa-chè is much higher than that which is manufactured with kaolin.

Material for glazing porcelain.

The principal ingredients in the fabrication of porcelain are petuntse and kaolin; but to these must be added the glaze or varnish, or, as it is called in the account given of Chinese porcelain, the oil, on which depend its splendour and whiteness. This varnish is of a whitish colour, and is obtained from the same kind of stone which yields the petuntse; but for this purpose the whitest stone is always preferred. The glaze is obtained by a process similar to that which is followed in the preparation of petuntse. The stone is first washed and reduced to powder; it is then thrown into a vessel filled with water, and after being purified, a frothy matter rises to the surface. To 100 pounds of this matter, one pound of a substance called che-kao, is added. This latter is a saline substance, somewhat like alum, which is put into the fire, and allowed to remain till it become red hot, when it is reduced to powder. By the addition of this substance the glaze acquires a greater degree of consistence; but at the same time a proper degree of fluidity must be preserved. The glaze prepared in this manner is not employed alone. Another glaze is mixed with it, which is obtained from lime and ashes; to 100 pounds weight of which is also added one pound of che-kao, or the aluminous substance mentioned above. When the two substances are mixed, it is necessary to attend that they be nearly of the same consistence, and the workman ascertains this point by dipping into each of them some cakes of petuntse; and by a close examination of their surfaces after they are drawn out, he is able to judge of the consistence of the fluids. The proportions of the two which are usually employed, are ten parts of the glaze obtained from the stone, to one of that which is prepared from the lime and from ashes.

Porcelain.

In the manufacture of the Chinese porcelain, the first process, after the separate preparation of the materials, is a second purification of the petuntse and kaolin; and when these are found to be in a state of sufficient purity, the workmen proceed to mix the two ingredients together. The proportions employed for the finer kinds of porcelain are equal parts of kaolin and petuntse; for an inferior kind, four parts of kaolin to six of petuntse are employed; and in some kinds of porcelain, only one part of the former is added to three of the latter. This is the smallest proportion of kaolin which is employed in the Chinese manufactories. When the proportions are fixed, and the mixture finished, the mass is thrown into a large pit, which is well paved and cemented. It is then trodden upon, and kneaded till it become hard. This is the most fatiguing part of the labour, for it must be continued without intermission. From the mass prepared in this manner the workmen detach different pieces, which they spread out upon large slates, where they knead and roll them in all directions, taking care that no vacuum be left, and that there be no intermixture of any foreign body. The whole work would be entirely spoiled by the addition of a hair, or a particle of sand. When the paste has been properly prepared, the porcelain, when exposed to heat in the furnace, retains its form without becoming soft, or entering into fusion, and becomes semitransparent, without exhibiting cracks or superficial fissures; but when there is any defect in the mixture or preparation, the porcelain cracks, and becomes warped, or melts in the furnace.

Proportion and mixture of the ingredients.

Methods of forming porcelain ware.

The paste being thus prepared, the next operation is to form the vessels for which it is designed. All kinds of plain ware are formed with the wheel. When a cup, for instance, has undergone this operation, the outside of the bottom is quite round. The workman first gives it the requisite height and diameter, and it comes from his hands almost the moment he has received it. Great dexterity and expedition are absolutely necessary, on account of the low price of labour in these manufactories. A workman, it is said, scarcely receives a farthing per board, each board containing no less than twenty-six pieces. The cup then passes to a second workman, by whom the base is formed; after which it is delivered to a third, who applies it to the mould, and gives it the proper form. When it is taken off the mould, it must be carefully turned, and not pressed more to one side than the other; for without this necessary precaution it would become warped or disfigured. The business of the fourth workman is to polish it with the chisel, especially round the edges, and diminish the thickness, in order to give it the proper degree of transparency. Having at length passed through the different hands from whom it receives its form and various ornaments, it then comes to the last workman, who forms the bottom with a chisel. It is wonderful, we are told, to see with how much dexterity and expedition the workmen convey the vessels from one to another; and it is added, that a single piece of porcelain, before it is completely finished, must pass through the hands of no fewer than seventy different workmen. It is indeed, we may observe, to this minute division of labour that its low price is owing; and on the same circumstance depend the remarkable dexterity and expedition which have already been noticed.

Of large works.

In the execution of large works of porcelain, different parts are first formed individually; and when all the pieces are finished, and nearly dry, they are put together and cemented with a paste formed of the same substance, and softened with water. Some time afterwards the seams are polished with a knife on both sides of the vessel, so that when it is covered with a varnish, or glazed, they are so completely concealed, that the least trace of them is not perceptible. It is in this way that spouts, handles, rings, and other parts of a similar nature, are united. And in this way

particularly are fabricated those pieces which are formed upon moulds, or by the hand, such as embossed works, grotesque images, idols, figures of trees or animals, and busts. All these are formed of four or five pieces joined together, which are afterwards brought to perfection by means of instruments proper for carving, polishing, and finishing the different traces which the mould has left imperfect. Flowers and ornaments which are not in relief, are either engraved, or the impression is made by means of a stamp; but ornaments in relief are prepared separately, and added to the pieces of porcelain to which they are destined.

Painting.

The piece of porcelain being prepared according to the operations now described, is next conveyed to the painter; and in this art it is to be observed that the Chinese workmen follow no certain rule, and seem to be unacquainted with any of the principles of perspective. Their knowledge is the effect of practice, guided often by a whimsical imagination. The labour of painting porcelain in the Chinese manufactories is also divided amongst a great number of hands. The business of one man, for instance, is solely limited to the tracing out the first coloured circle with which the brim of the vessel is adorned; another designs the flowers, and a third paints them. One delineates waters and mountains, whilst it is the province of another to draw and paint birds and other animals. Of the painting on Chinese porcelain, it has been observed, that the human figure is often most indifferently executed.

Veined porcelain and fret-work.

A peculiar kind of glaze or varnish, we are informed, is obtained from white flint. This glaze, it is said, has the singular property of making the pieces of porcelain to which it is applied exhibit the appearance of veins distributed in all directions. Vessels glazed with this material seem as if the surface were cracked, without the fragments being separated or displaced. The colour of this glaze is whitish gray; and when it is applied to porcelain having an azure blue ground, it communicates a beautifully-variegated appearance. Vases of Chinese porcelain are sometimes fabricated in a different manner. They are ornamented with a kind of fret-work, which has something of the appearance of fine lace, in the middle of which is placed a cup proper for holding any liquid; which constitutes one body with the surrounding fret-work.

Singular kind of porcelain.

We are informed that the Chinese workmen formerly possessed the secret of fabricating a kind of porcelain of a much more singular nature. On the sides of the vessel thus formed were painted the figures of fishes, insects, and other animals, which could not be seen unless the vessel was filled with water. It is said that this secret is in a great measure lost; but the following is given as part of the process of preparing this kind of porcelain. The vessel which is to be painted, for the purpose of producing this peculiar effect, must be extremely thin and delicate. When it is dry, the colour is laid on, not upon the outside, however, as is usually the case, but upon the inside of the vessel; and it is laid on pretty thickly. The figures which are painted upon it are usually fishes, as being more characteristic of the element in which they live. When the colour is perfectly dry, it is then coated over with a kind of glaze, composed of porcelain earth, so that the azure is thus enclosed between two layers of earthy matter; and when the glaze becomes dry, the workman pours some oil into the vessel, and putting it upon a mould, applies it to the lathe. Porcelain fabricated in this manner, having received its consistence and body within, it is the object of the workmen to make it as thin as possible on the outside, without penetrating to the colour. The external surface is then dipped into a mixture for glazing, and when it is dry it is baked in a common furnace. This kind of porcelain is known by the name of *kia-tsing*, signifying pressed azure. It is supposed that the Chinese do not at present possess the art of making porcelain of this description, which requires a great deal of dexterity and delicate management; and it is added, that they have imperfectly succeeded in the attempts which have been occasionally made to discover the secret of this curious process.

Chinese furnaces.

The next process in the manufacture of porcelain is baking; but before we describe the method of arranging and managing the furnaces employed for this purpose, we shall give a short account of their construction. The Chinese furnaces for baking porcelain are furnished with a long porch, for the purpose of conveying air, and in some measure as a substitute for bellows. This porch answers the same purpose as the arch of a glass-house; but the furnaces which, as the author from whom the account is taken observes, were formerly only six feet in height, and the same in length, are now constructed upon a much more extensive plan. They are twelve feet in height, and nearly four in breadth; and the roof and sides are so thick, that the powerful heat which is applied internally does not penetrate to the outside, at least so much as to be inconvenient to bear it on the application of the hand. The dome or roof is in the form of an inverted funnel, having a large aperture at the top by which the smoke escapes. Beside the principal aperture, there are five others of smaller dimensions, which are covered with broken pots in such a manner that the workman can increase or diminish the heat as he finds it necessary. Through these apertures also he is able to see the progress of the baking of the porcelain, and can judge when it is completed. By uncovering the hole which is nearest the principal opening, he opens with a pair of pincers one of the cases containing the pieces of porcelain, and if he perceives a bright fire in the furnace, and all the pieces brought to a red heat, as well as the colours of the porcelain appearing with a full lustre, he concludes that the process is finished. He then diminishes the fire, and entirely shuts up the mouth of the furnace for some time. In the bottom of the furnace there is a deep hearth about two feet in breadth, over which a plank is laid, in order that the workmen may enter to arrange the porcelain. When the fire is kindled on the hearth, the mouth of the furnace is immediately closed up, and an aperture is left only sufficient for the admission of faggots, about a foot in length, but very narrow. The furnace is first heated for a day and a night, after which two men keep continually throwing wood into it, and relieve each other by turns. One hundred and eighty loads are consumed for one baking. As the porcelain is burning hot, the workman employs for the purpose of taking it out, long scarfs or pieces of cloth, which are suspended from his neck.

Method of baking porcelain.

Having thus given a concise account of the construction of the Chinese furnaces, we proceed now to lay before our readers an account of the method of baking porcelain which is followed in that country. After the porcelain has received its proper form, its colours, and all the intended ornaments, it is transported from the manufactory to the furnace, which is sometimes situated at the other end of the village already mentioned. In a kind of portico, which is erected before it, may be seen vast numbers of boxes and cases made of earth, for the purpose of inclosing the porcelain. Each piece, however inconsiderable it may be, has its own case; and the Chinese workman, by means of this procedure, imitates nature, which, in order to bring the fruits of the earth to maturity, clothes them in a covering, to defend them from the excessive heat of the sun during the day, and from the severity of the cold during the night.

A layer of fine sand is put into the bottom of these boxes, which is covered over with the powder of kaolin, to prevent the sand from adhering too closely to the bottom of the vessel. The piece of porcelain is then placed upon this bed of sand, and pressed gently down, in order that the sand may take the form of the bottom of the vessel, which does not touch the sides of its case; but the case has no cover.

Porcelain. A second, prepared in the same manner, and containing its vessel, is fitted into the first, so that it entirely shuts it, without touching the porcelain which is below; and thus the furnace is filled up with piles of cases, which defend the pieces they contain from the direct action of the fire.

With regard to small pieces of porcelain, such as tea-cups, they are inclosed in common cases about four inches in height. Each piece is placed upon a saucer of earth about twice as thick as a crown piece, and equal in breadth to its bottom. These small cases are also sprinkled over with the dust of the kaolin. When the cases are large, the porcelain is not placed in the middle, because it would be too far removed from the sides, and consequently from the action of the fire.

These piles of cases are put into the furnace, and placed upon a bed of coarse sand six inches in thickness; those by which the middle space is occupied are at least seven feet in height. The two boxes which are at the bottom of each pile remain empty, because the fire acts too feebly upon them, and because they are partly covered by the sand. For the same reason, the case which is placed at the top of each pile is also allowed to remain empty. The piles containing the finest porcelain are placed in the middle part of the furnace; the coarsest are put at its farthest extremity; and those pieces which have the most body and strongest colouring are near its mouth. These different piles are placed very closely in the furnace; and they materially support each other by pieces of earth, which bind them at the top, bottom, and middle, but in such a manner, that a free passage is left for the flame to insinuate itself everywhere around them.

Different kinds of porcelain. The Chinese divide their porcelain into several kinds or classes, distinguishing each according to the different degrees of beauty and fineness. The whole of the first or most perfect kind is reserved for the emperor; none of it, we are assured, ever comes into the hands of the public, unless, on account of blemishes or imperfections, it is unworthy of being presented to the sovereign. Many have doubted whether at any time the largest and finest porcelain of China has ever been brought to Europe. None of that kind, at least, is offered for sale at Canton. The Chinese, who are apt to undervalue the productions of other countries, entertain a favourable opinion of the Dresden porcelain, and hold in still higher estimation the porcelain which is produced in the French manufactories.

Sir George Staunton's account of the manufacture of porcelain in China. The following is a short account of the Chinese porcelain manufactures by Sir George Staunton. "From the river," says he, "were seen several excavations made in extracting from the sides of the adjoining hills, the petuntse useful in the manufacture of porcelain. This material is a species of fine granite, or compound of quartz, feldspar, and mica, in which the quartz seems to bear the largest proportion. It appears from several experiments, that it is the same as the growan stone of the Cornish miners. The micaceous part, in some of this granite from both countries, often contains some particles of iron, in which case it will not answer the potter's purpose. This material can be calcined and ground much finer by the improved mills of England, than by the very imperfect machinery of the Chinese, and at a cheaper rate than the prepared petuntse of their own country, notwithstanding the cheapness of labour there.

"The kaolin, or principal matter mixed with the petuntse, is the growan clay also of the Cornish miners. The whashe of the Chinese is the English soap-rock; and the shekan is asserted to be gypsum. It was related by a Chinese manufacturer of that article, that the asbestos, or incombustible fossil stone, entered also into the composition of porcelain. A village, or unwalled town, called Kin-te-chin, was not very far distant from this part of the present traveller's route, in which 3000 furnaces for baking porcelain were said to be lighted at a time, and gave to the place at night the appearance of a town on fire. The genius or spirit of that element is indeed, with some propriety, the principal deity worshipped there. The manufacture of porcelain is said to be precarious, from the want of some precise method of ascertaining and regulating the heat within the furnaces, in consequence of which their whole contents are baked sometimes into one solid and useless mass. Mr. Wedgwood's thermometer, founded on the quality observed by him, of clay contracting in proportion to the degree of fire to which it is exposed, might certainly be of use to a Chinese potter."

Porcelain.

2. *Inquiries of Reaumur into the Nature of Porcelain.*

Composition of porcelain examined. The first scientific investigation which was made into the nature of porcelain, was undertaken by the celebrated Reaumur; and the result of his researches was communicated to the French Academy of Sciences in the years 1727 and 1729. It was not the external form or appearance, nor was it the decorations of painting and gilding, which are by no means essential to porcelain, that constituted the object of his inquiries. His examination was particularly directed to the peculiar texture and fabric of this substance, with the view of ascertaining the nature and proportions of its constituent parts. For this purpose, he broke to pieces some of the Japanese, the Saxon, and the French porcelains, and carfully noted the peculiarities and differences in their texture. The grain or texture of the Japanese porcelain appeared to possess a considerable degree of closeness and compactness, with a smooth and somewhat shining aspect. He found that the Saxon porcelain was still more compact, and that it was smooth, and shining like enamel, but had nothing whatever of the granular texture. In his examination of the French porcelain, he observed that it had much of the shining appearance, and that its grain was not so close and fine as that of the oriental porcelain, having some resemblance to the grain or texture of sugar. Such were the observations which occurred to the French philosopher at the commencement of his inquiries into the nature of porcelains; and hence he justly concluded, that they were characterised by very marked differences.

Effects of heat on porcelain. Proceeding in his investigation, the same philosopher subjected different porcelains to the action of heat; and the result of his experiments with this powerful agent proved, that they might be distinguished by still more decisive characters. It appeared that the porcelain of the East suffered no change from the action of the greatest heat, whereas that of European manufacture underwent fusion at no very high temperature. This remarkable difference between the Chinese and European porcelains, suggested to Reaumur an ingenious thought, which at last led him to the discovery of the true nature of the composition of porcelain. Having observed that all porcelains have some resemblance to glass in some of their general properties, although they are less compact, he considered them as in the state of a semi-vitrified substance. An earthy substance, he observed, may be in a semi-vitrified state in two ways. It may, in the first place, be entirely composed of vitrifiable or fusible matters; and this being the case, when it is exposed to the action of fire, provided the heat be sufficiently strong and long continued, it will be melted or vitrified. But as this change is not effected instantly, particularly where a violent degree of heat is not applied; and as it passes through different degrees, the progress of which may be more easily observed, according as the heat is managed and regulated, it followed, that by stopping in proper time the application of the heat to porcelain prepared in this way, the ware may be obtained in an intermediate state between those of crude earths and completely vitrified substances; whilst, at the same time, it possesses the semitransparency and other distinguishing properties of porcelain. Porcelain of this nature, it is well known, being exposed to a stronger degree of heat, undergoes perfect fusion and complete vitrification. All

Porcelain. the European porcelains which were subjected to experiment by Reaumur, were found to be of this fusible nature.

Porcelain composed of fusible and infusible matter.

But on the other hand, porcelain may be composed of fusible or vitrifiable matter, mixed in certain proportions with another matter, which is absolutely infusible in the strongest heat to which it can be exposed in the furnace; and hence, if a mixture of this kind be subjected to a heat sufficient to melt entirely the vitrifiable part of its composition, this will enter into fusion; but being mixed with another matter which is infusible, and which consequently retains its consistency and opacity, the whole will form a compound, partly opaque, and partly transparent, or, in other words, a semitransparent mass; that is, a semivitrified substance, or porcelain, but possessing qualities totally distinct from those of the former. For as the fusible part of the latter has been brought to its utmost degree of fusibility during the process of baking, although the compound may be exposed a second time to a still stronger degree of heat, it will not approach nearer to complete vitrification, that is, it will retain all the qualities of perfect porcelain. Reaumur found that the porcelain of the East was distinguished by the properties now described; and hence he concluded, that its component parts were arranged upon the principle above mentioned. This opinion was afterwards confirmed by incontrovertible facts, deduced from a train of the most satisfactory and well directed experiments.

Kaolin infusible, and petuntse a vitrifiable matter.

The ingredients which enter into the composition of the Chinese porcelain, namely, the petuntse and kaolin, were the next object of Reaumur's inquiries. Having obtained quantities of each, he subjected them separately to a strong heat, and he found that the petuntse entered into fusion, without addition; but it appeared that the kaolin was absolutely infusible. He then mixed the two ingredients, formed into cakes, and exposed them in a furnace to the proper degree of heat; so that by baking they were converted into porcelain exactly similar to that of the Chinese. From these experiments it appeared, that the petuntse of the Chinese was a vitrifiable substance, and that the kaolin was of a different nature, quite refractory, and totally infusible. After this discovery, Reaumur, it would seem, entertained hopes that he might find materials in France, capable of making porcelain, which should possess the same valuable qualities as that of China; but whether his researches in the discovery of proper materials in his own country, particularly that which corresponds to the petuntse of the Chinese, were baffled, or whether he was prevented by other avocations from prosecuting his inquiries, does not appear. In his second memoir upon porcelain, however, we find, that he afterwards attempted to compose an artificial petuntse, by mixing vitrifiable stones with such saline bodies as were capable of rendering them fusible, or even by substituting for this artificial preparation glass ready formed, with the addition of such matters as he supposed might be successfully employed in the place of kaolin. But it would appear that he did not at the time prosecute his inquiries; for the subject was not resumed until the year 1739, when he announced the discovery of a process for converting common glass into a peculiar kind of porcelain, which has been since known by the name of *Reaumur's porcelain*.

Mistakes of Reaumur.

Although it must appear, from the detail now given, that Reaumur was directed in his researches by the true spirit of philosophical inquiry, he seems to have been misled in certain points. One of his errors was relative to the Saxon porcelain, which he confounded with the other fusible porcelains of European manufacture, unless it be supposed that the porcelain of Saxony was formerly composed of entirely fusible or vitrifiable matters, and that it was porcelain of this description which he examined; for it is now certain, that all the porcelain of that country is capable of resisting the most powerful heat, and is therefore equally infusible with that of China or Japan. The appearance of the internal texture of the Saxon porcelain may perhaps have led the philosopher to this erroneous conclusion; for when it is broken, the internal surface does not exhibit a granular texture, but is uniform, smooth, shining, and compact, having a great resemblance to white enamel. This appearance, however, so far from proving that the porcelain of Saxony is a fused or vitrified substance, shews that it is not entirely composed of fusible matters. The internal surface of the most fusible porcelains, it is well known to those who are acquainted with the subject, is also the least dense, and the least compact; for no vitreous matter can be internally smooth and dense, without having been in a state of complete fusion. Porcelain.

The Saxon, like every other porcelain, especially that of China and Japan, contains a fusible substance, which has been in a state of complete fusion during the process of baking. The density and the internal lustre depend chiefly on this fused matter; but it is also certain, that the Saxon porcelain contains a large proportion of a substance which is absolutely infusible, and from which it derives its beautiful white appearance, its firmness and solidity, during the process of baking. It is this infusible substance which is to be considered as the substitute for the kaolin of China, and which possesses the property of contracting its dimensions, whilst it unites with the fusible material. The Saxon porcelain, therefore, is not to be confounded with porcelain manufactured with vitreous and fusible material; for it seems to be equally excellent as that of Japan, and in some of its properties perhaps superior, as will appear from an examination of the qualities which constitute the peculiar excellence of porcelain.

Reaumur seems likewise to have taken an erroneous view of the nature of the Chinese kaolin. According to his account, this matter is a fine talcky powder, from the mixture of which with petuntse, the porcelain of the East is manufactured. It is not impossible, as has been observed, that a porcelain similar to the Chinese might be produced from a talcky substance of this nature mixed with petuntse; but it is well known to those who are at all familiar with the manufacture of any porcelain, that no vessels can be formed, unless the paste of which they are made possess that degree of ductility and tenacity which renders them fit for being worked upon the lathe, or fashioned in the mould. But substances of a talcky nature, to whatever degree of fineness they may be reduced, never acquire the requisite ductility and tenacity which clays of all earthy substances only possess. But as it appears that the Chinese porcelain has been turned upon the lathe, it is obvious that they must have been formed of a very tenacious paste; and hence it is concluded, that kaolin is not purely a talcky matter, but an infusible clay, which, with the petuntse, a fusible material, forms the ingredients which enter into the composition of Chinese porcelain.

3. *Peculiar Properties of Porcelain.*

Essential qualities of porcelain.

It may be worth while now to consider what are the properties which constitute the perfection of porcelain; and here it is necessary carefully to discriminate between the qualities which are to be regarded as only contributing to the external decoration, and the intrinsic and essential properties in which the fabric and perfection of porcelain consist. Those who have been occupied in experiments upon this subject, have not found it difficult to form compositions which are very white, beautifully semi-transparent, and covered with a shining glazing, but which are extremely deficient in the more essential properties. It appears, indeed, that they cannot be subjected to the necessary operations in first forming the ware, for want of a proper degree of tenacity, that they are not sufficiently compact, and are quite fusible, subject to break by the sudden application of heat or cold, and from the softness of the glazing, which cracks and becomes rough, are

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soon deprived of their lustre. On the other hand, it is by no means difficult to form compositions of pastes, which are very tenacious, and which are capable of being easily worked and well baked, and in the process of baking which acquire the requisite degree of hardness and density; which are infusible, and capable of resisting the effects of sudden changes of heat and cold; and which, in short, possess all the qualities of the most excellent porcelain, excepting its whiteness and transparency. Materials fit for the composition of such porcelains, it will appear, may be found in abundance in most countries; but those fit for the manufacture of the finer and more perfect porcelains, seem to be sparing productions of nature; and therefore the best kind of porcelain, it is presumed, will always be regarded as a valuable and high-priced commodity.

Nature of stoneware.

It may be observed that the potteries called *stoneware*, such as the brown made at Lambeth and some other places, and the white formerly made at Burslem in Staffordshire, which were glazed by salt, or muriate of soda, being thrown into the furnace when in a state of high fusion, possess all the essential qualities of the Japanese porcelain; for, excepting the whiteness, on which alone the semitransparency depends, if we compare the properties of the Japanese porcelain with those of our stoneware, little difference is found to exist between them. Both seem to possess the same granular texture; both have the same sonorous quality, when struck with a hard body; both have the same density; they possess also the same hardness, by which they strike fire with steel; they can resist the effects of the heat of boiling liquors without breaking, and are equally infusible when subjected to the most violent heat. Hence it is inferred, that if the earth which enters into the composition of stoneware, were free from foreign colouring matters, which prevent the whiteness and semitransparency, and if the vessels were carefully formed and covered with a very fine glaze, they would not be less perfect than the porcelain of the East. (See POTTERY.) Earths fit for the production of the more perfect kinds of porcelain are supposed to be more rare in Europe than in Japan and China; and hence probably it has happened, that, from the want of these earths, the first manufacturers of the porcelain in Europe confined themselves to an external imitation, by employing only vitrifiable matters with fusible salts, and small quantity of white earth, of which fusible and vitreous porcelains were composed.

One of the most valuable qualities of porcelain is the property of resisting sudden alternations of heat and cold, in which the European porcelain exceeds that of China or Japan. The quality of porcelain, it is to be observed, is not to be judged of by a slight trial; for as numerous circumstances concur to render a piece of porcelain capable or incapable of resisting the effects of heat or cold, boiling water may be at the same time poured into two vessels, one of which is good porcelain, and the other of an opposite quality, it is not impossible that the former may break, and the latter may remain entire. The true method of discovering what is good porcelain, is to examine several pieces which are in daily use; and it has been found, that in many pieces of porcelain of oriental manufacture, which have been long used, cracks are seen in the direction of their height, which are never perceived in the more perfect porcelains of European manufacture.

Japanese porcelain formerly reckoned the most perfect.

It has long been a very general opinion, that the Japanese porcelain is the most perfect; it has indeed continued to be the object of admiration and emulation, and has been held up as a model for the European manufacturer. But the taste of Europeans having required a porcelain possessing the qualities of transparency and whiteness in a greater degree than that of Japan, the attempts to imitate it have been mostly confined to experiments. It has therefore been erroneously contended that an article equal to the Japan porcelain cannot be produced in Europe. The Saxon porcelain has been considered as inferior to the Japanese, on account of its greater smoothness, lustre, and less granular aspect of its internal texture; qualities in which it ought really to be regarded as superior to the porcelain from Japan.

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4. *Porcelain Manufactories in different parts of Europe.*

Manufactories of porcelain have been long established in almost every country of Europe, but from the experiments of Reaumur it would appear that the only kind then manufactured was the soft porcelain, or *porcelaine tendre*. It has been seen that the Saxon manufacturers charged him with mistake in classing theirs with the soft porcelain; but by admitting that he might have operated upon an article formerly made by them, it is proved that all European porcelain was originally of this kind. Besides that of Saxony, which was the first established in Europe, porcelain is made to a considerable extent at Vienna, at Frankendal, in the neighbourhood of Berlin, and in other places in the German states. The German porcelains are similar to those of Saxony, and are composed of similar materials, although from certain differences in the proportions, or in the modes of managing the manufactories, considerable differences arise in the porcelains manufactured at different places. When M. de la Condamine travelled into Italy, he visited a manufacture of porcelain established at Florence by the Marquis de la Ginor, who was at that time governor of Livorno. The French traveller was particularly struck with the large size of some of the pieces of this porcelain. Statues, and even groups of figures half as large as nature, and modelled from some of the finest antiques, were formed of it. The furnaces, he observed, in which the porcelain was subjected to the process of baking, were constructed with a great deal of ingenuity, and were lined with bricks made of the same materials as those which entered into the composition of the porcelain itself; and hence they were able to resist the effects of high degrees of heat. The paste of the porcelain manufactured at Florence appeared to be extremely beautiful, and to possess all the qualities of the best oriental porcelain. The glazing employed in this manufactory seemed to be inferior in whiteness, a circumstance which is supposed to be owing to the desire of using those materials only which are found in the country.

Manufactures of porcelain in France.

It must be allowed that the labours of the French have been crowned with wonderful success in the improvement and perfection of this manufacture. Some time before even Reaumur communicated the result of his inquiries, porcelain was manufactured at St. Cloud, and also in the suburb of St. Antoine at Paris. This porcelain indeed was of the vitreous or fusible kind, but at the same time it possessed no inconsiderable degree of beauty. Since the period to which we allude, extensive manufactories of porcelain have been established at Villeroy, Chantilly, and Orleans, and at those places the manufacture has been brought to a high degree of perfection. But the great seat of the manufacture is now in the Limousin, where the raw materials are found, and whence the porcelain in a white state is sent to Paris and other places on the continent, to be ornamented. The productions of the celebrated royal porcelain manufactory at Sèvres, near Paris, on account of the pure shining white, the fine glazing and coloured grounds, the splendour and magnificence of the gilding, and the elegance and taste displayed in the shape and figures, are universally allowed to surpass every thing of the kind which has yet appeared. It must be remarked, however, that this manufactory at Sèvres, wherein the "*porcelain dure*" is produced in so great a degree of perfection, is not carried on with a view to profit, but has received occasional grants of money from the government, as a national concern.

In speaking of the French porcelain, we may notice the result of some researches which were made on this subject

Porcelain. by Guettard, and of which an account appeared in the Memoirs of the Academy of Sciences, for the year 1765. In the neighbourhood of Alençon, M. Guettard discovered a whitish argillaceous earth, in which he found that mica considerably predominated. This earth he employed as a substitute for kaolin. The substance which he used instead of the petuntse, he obtained from a hard stone, which is described as a quartzose gritt stone, very abundant in that country, and with which the streets of Alençon are paved. With these materials Guettard instituted a series of experiments on porcelain, previously to the year 1751, and was associated in his inquiries with the Duke of Orleans. For many years the Count de Lauraguais, a member of the Academy of Sciences, was keenly engaged in prosecuting experiments to discover the true nature of porcelain, and the means by which the manufacture might be improved and perfected. To obtain the object of his researches, which was to produce porcelain that in its essential qualities might be equal to that of eastern countries, he spared no trouble or expense; and it would appear that he was not unsuceessful in his labours; for in the year 1766, when he exhibited some species of porcelain from his manufactory to the members of the Academy of Sciences, the persons who were appointed by that learned body to examine their properties, delivered it as their opinion, that of all the porcelain made in France, that of the Count de Lauraguais approached most nearly in the essential properties of solidity, texture, and infusibility, to that of China and Japan. It is said, however, that it was considerably deficient in whiteness and lustre, when compared with the ancient porcelain of Japan. The great interest, however, created in France in support of this elegant and useful fabric, the continued experiments of the ablest chemists and scientific men, with the discovery of better materials which are abundant in the South of France, gave to that country facilities which enabled her soon to take the lead of the continent and of Britain in the production of this article.

Manufactory at Tournay. Porcelain manufactories have long been established at Tournay in Flanders. One of these manufactories furnishes all Flanders with blue and white porcelain. At this manufactory they have a particular process in forming cups and other vessels. They are neither turned on the lathe, nor is the clay compressed in a mould; but after being diluted in water, and when the liquid has acquired a proper consistency, the workmen pour it into moulds, two or three hundred of which are arranged together. When they have filled them all, they return to the first in the row. The liquid part is drawn off by a gentle inclination; the surplus adheres to the side of the vessel, and thus forms the piece which it is intended to make. The piece is detached from the mould by means of a slight stroke; and after being sufficiently dried, it is conveyed to the furnace, to undergo the process of baking.

In England In England but little progress was made in the manufacture of porcelain, until towards the end of the last century. At an earlier period there was a manufactory carried on by some Germans at Chelsea, afterwards removed to Derby, of porcelain of a very superior quality; but whence they derived their materials is now uncertain. The porcelain which was then made at Liverpool, and some other places, was of an inferior kind, and manufactured so thin, in order to procure transparency, as to render it in a great degree unserviceable. This porcelain was made of the clays from Devonshire, to which a frit, described hereafter, was added to improve the colour of the body, and to create that degree of transparency which was required by the public as a principal attribute of porcelain.

About the year 1768, the discovery in Cornwall of mines of clay and stone similar to those used in France and Germany, and which are believed to be the kaolin and petuntse of the Chinese, soon enabled the English manufacturer to improve his porcelain, by discontinuing the use of frit, or glass, as a component part of the basis or body of the ware, and substituting a mixture of the fusible and infusible earths as the basis of his porcelain, as had been done, at a much earlier period, in Germany and France. And thus the English porcelain, in many of its essential qualities, particularly in the beauty and richness of its paintings and gildings, as well as the elegance of its forms, has become little, if at all inferior, to that of any other country. Porcelain.

There are in England a number of manufactories of porcelain, at Derby, at Worcester, at Coalbrookdale, and at Rotherham, in Yorkshire. But the principal site of this manufacture is now in the Staffordshire Potteries, where it is produced in large quantities, at various manufactories.

5. *Different Processes in the Manufacture of Porcelain.*

Bases. The basis of those porcelains which were respectively known by the name of *vitreous*, *fusible*, and *soft* porcelain, was in part composed of what was called a *frit*; that is to say, a mixture of alkalis and siliceous earths, brought into fusion, which, forming an opaque glass, was ground very fine, and mixed with an infusible earth or clay, in quantity sufficient to produce a degree of fusion, and consequent transparency of the whole body, but not so much as to prevent the ductility necessary for the formation of the articles to be made. The basis of the porcelains now generally made is composed of a mixture of infusible and fusible earths, in those proportions which, on the application of intense heat, produce that transparency and semi-vitrification which is required as the distinguishing properties of porcelain.

Manipulation. Up to a certain point, the operations and manipulations are the same in all cases. The clay or infusible earth having been separated by washing from the mass of decomposed granite, of which it forms a part, is mixed with a portion of the fusible earth, finely livigated into a liquid of the consistence of cream, which, after being passed through the finer silk lawns, is placed on kilns to evaporate the superfluous water, until the mass becomes a soft tenacious paste, ready for the operations of the workman. It is then taken to the thrower, to be fashioned on his wheel; and having obtained a sufficient degree of hardness to preserve its form, is transferred to the lathe to be more correctly shaped, and the surface made even. It next has handles, feet, and other requisites added, and is then ready to receive its first firing. To effect this, it is, when sufficiently dry, put into a case made of earthen ware, and placed in the furnace, that it may be subjected to the process of baking. These cases are known amongst the English potters by the name of *seggars* or *saggars*, and they are generally formed of a coarser kind of clay; but this clay must possess the property of resisting the action of heat necessary for the baking of porcelain, without being fused. The porcelain contained in the cases is thus protected from the smoke of the burning fuel. The whiteness of the porcelain depends greatly on the purity of the clay of which the *saggars* are made, so that being of a more compact texture, the smoke is more effectually excluded. These cases are arranged in the furnace or kiln in piles, one upon the other, to the top of the furnace.

A small fire is first made, that the furnaces may be gradually heated; and it is increased more and more until the process of baking is completed, that is, until the porcelain shall have acquired a proper degree of hardness and transparency. To ascertain this point, much attention is necessary, by taking out of the furnace from time to time, and examining, small pieces of porcelain placed for that purpose in some cases, which have lateral openings in the walls of the furnace to render them accessible. When it appears, from the examination of those pieces, that the porcelain is sufficiently baked, the fire is no longer to be supplied with fuel; the furnace is allowed to cool gradually, and the porcelain is afterwards taken out.

But at this point of the process of baking, or firing, the

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modes adopted in France, and on the continent generally, are materially different from the practice in this country; in fact, are totally reversed. In England the first, or biscuit firing, is employed to produce, by an intense heat, the required degree of transparency and vitrification; whilst in France but a small degree of heat is applied, sufficient only to harden *(degourdir)* the ware, so that it may bear the manipulation necessary before the glazing, without breaking, the transparency and strength being obtained at the second operation of firing, which, like the English biscuit-firing, requires an intense heat to accomplish that object.

Unglazed porcelain called biscuit.

Unglazed porcelain has the appearance of white marble, having nothing of that shining surface which it acquires by covering it with the vitreous composition called glaze, and is said to be in the state of *biscuit*. For particular purposes, the porcelain is sometimes allowed to remain in this state, and particularly when it is employed in smaller and finer pieces of sculpture, where the fineness of the workmanship and the sharpness of the figures are wished to be preserved, as it is well known that these will be greatly injured by being covered with a coat of glazing. The celebrated manufactory of Sèvres has long been distinguished for figures or small statues, and even for larger works, as ornamental vases, &c., which are left in the state of biscuit. The English manufactories are probably not inferior in the delicacy and accuracy of execution of ornamental productions of this kind.

Method of glazing porcelain.

The next operation in the manufacture of porcelain is the process of glazing. This process consists in covering the porcelain with a thin coat of vitreous or fusible matter, which adds greatly to its beauty, by its lustre or shining appearance. In preparing and applying the materials fit for glazing porcelain, it has been found that the same mixture will not admit of general application; for it appears, that what forms a fine glazing for one kind of porcelain, will not answer the same purpose when applied to another. In the former it may have all the necessary requisites, but in the latter it may crack in many places, may have no lustre, and may contain bubbles, or be apt to scale off. The first thing, then, is to prepare a glaze which shall be suited to the nature of the porcelain for which it is intended. The glazing must be appropriated to each kind of porcelain, that is, to the ingredients which enter into its composition, or to the degree of hardness or density of the ware. The materials of which the glazing is composed are prepared by previously fusing together all the substances of which they consist, and thus forming a vitreous mass. This mass of vitrified matter must be finely ground in a mill, and the vitreous powder thus obtained be mixed with a sufficient quantity of water, so that the liquor shall have the consistence of cream of milk. The pieces of porcelain are to be covered with a thin coating of this matter, which is done by immersing them hastily in the liquid, and as they greedily imbibe the water, there remains on the surface a uniform covering of the glazing materials. This covering, which, it must be observed, should be very thin, in a short time becomes so dry, that it does not adhere to the fingers when the pieces are handled. When they are sufficiently dry, they are replaced in the furnace in the same manner as in preparing the biscuit, and the heat is continued till the glazing be completely fused; but the degree of heat necessary for that purpose is far inferior to that which is requisite in baking the paste. As before noticed, however, this does not apply to the French porcelains, the glazing of which is effected by a higher degree of heat than what is applied to the paste or body.

The glaze used for the soft porcelain possessed great advantages in the execution of the more delicate paintings and decorations, by its property of assisting to flux and fix with more certainty the metallic oxides of which the colours are composed. The old Sèvres china is of this description. But at that royal manufactory, under the able direction of M. Brogniat, the *porcelaine dure*, now the only kind made there, has been so much improved, as to admit of its being embellished by paintings of the most delicate and brilliant colours and superb grounds, with gilding equal, if not superior, to the old Sèvres.

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Of painting.

The pieces of porcelain which are intended to remain white are now finished, but those which are to be ornamented with painting and gilding must go through various other operations. The colours which are employed in painting porcelain on the glaze are similar to those which are applied in the painting of enamel. They are all composed of metallic oxides or calces, combined with a very fusible vitreous matter. The different colours are obtained from different metals. The oxides of iron afford a red colour; gold, precipitated by means of tin, furnishes a purple and violet colour; copper, precipitated from its solution in acids by means of an alkali, gives a fine green; cobalt, or when combined with vitreous matter, *zaffar*, as it is called, yields a fine blue. Earthy matters which are slightly feruginous, produce a yellow colour; and brown and black colours are obtained from iron in different states, and from manganese. The oxide of chrome, which has but lately come into use, has furnished artists with greens and some other colours, of a brilliancy and fixedness in the fire not before known. These colours are applied to the ware by the painters according to the requisite pattern, and it is again conveyed to the furnace, and the colours are vitrified, to give them the proper degree of fixation and lustre. In the common kind of porcelain, once or twice burning is sufficient, but in the finer decorations the colours must be laid on several times, and as often fired before the full effect can be produced. This process is similar to that practised by enamellers on copper, &c.; but the blue colour from cobalt is much used for painting on the biscuit ware before glazing.

Of printing.

The discovery of a method of imitating the painted patterns of the Chinese by impressions taken from engraved copper plates, was of great importance, as it enabled the European manufacturers to compete with the cheap labour of the Chinese. This discovery is due to a manufacturer at Liverpool, where porcelain was formerly made. The process is as follows. The pattern being engraved on a copper plate of the size wanted, it is charged with the colour to be used, which is mixed with boiled linseed oil; the plate is then placed on a hot stove, and a piece of thin tissue paper, previously primed with a solution on one side of soft soap, is laid upon the plate, and both passed through the rollars of the press as in ordinary printing. The impression is then taken off, and transferred on to the ware. After being well rubbed with a roller of flannel, to cause the colour and oil to adhere to the ware, the piece is then put into lukewarm water, where the paper, by the action of the soap, leaves the ware and the colour upon it. The ware is next dried, and subjected to a degree of heat, to evaporate the oils, and the ware is then in a condition for the glazing.

Gilding.

But when the pieces of porcelain are to be further decorated with gilding, they are pencilled with a mixture of oil and gold, dissolved or thrown down by quicksilver with the aid of heat, and are again introduced into the furnace. Here the gold returns to its solid state, but comes out with a dull surface; and to recover its lustre and usual brilliancy, it is burnished with blood-stones, and other polishing substances. Much care and attention are necessary in the latter part of the process; for if the gold be not sufficiently burned, it will be apt to separate in thin flakes; and if it have been exposed to too great a heat, it is not susceptible of a fine polish. In this manufactory, when pieces of porcelain are to be finished in the highest style, they are frequently returned to the enamel furnace, where the colours are fluxed six or seven different times; and having gone through the processes now described, the porcelain is fit for the market.

Use of platina in colouring porcelain.

The use of platina in porcelain painting has been recommended by Klaproth; and experiments have been made on the subject by that celebrated chemist, with the view of ascertaining its effects for this purpose. In concluding his observations, he says, "The process which I employ in the application of platina to painting on porcelain is simple and easy. I dissolve crude platina in aqua regia, and precipitate it by a saturated solution of sal-ammoniac in water. The red crystalline precipitate thence produced is dried, and being reduced to a very fine powder, is slowly brought to a red heat in a glass retort. As the volatile neutral salt combined with the platina in this precipitate becomes sublimated, the metallic part remains behind in the form of a gray soft powder. This powder is then subjected to the same process as gold; that is to say, it is mixed with a small quantity of the same flux as that used for gold, and being ground with oil of spike, is applied with a brush on the porcelain; after which it is burned-in under the muffle of an enameller's furnace, and then polished with a burnishing tool.

"The colour of platina burnt into porcelain in this manner is a silver white, inclining a little to a steel gray. If the platina be mixed in different portions with gold, different shades of colour may be obtained; the gradations of which may be numbered, from the white colour of unmixed platina to the yellow colour of gold. Platina is capable of receiving a considerable addition of gold before the transition from the white colour to yellow is perceptible. Thus, for example, in a mixture of four parts of gold and one of platina, no signs of the gold were to be observed, and the white colour could scarcely be distinguished from that of unmixed platina: it was only when eight parts of gold to one of platina were employed that the gold colour assumed the superiority.

"I tried in the like manner different mixtures of platina and silver; but the colour produced was dull, and did not seem proper for painting on porcelain.

"Besides this method of burning-in platina in substance on porcelain, it may be employed also in its dissolved state; in which case it gives a different result both in its colour and splendour. The solution of it in aqua regia is evaporated, and the thickened residuum is then applied several times in succession to the porcelain. The metallic matter thus penetrates into the substance of the porcelain itself, and forms a metallic mirror of the colour and splendour of polished steel."

General principles of the manufacture of Porcelain and Earthenware.

Convinced that every accurate and scientific investigation into the nature and processes of any important art, will always be deemed of some value to the philosophical observer, or the enlightened manufacturer, we shall introduce the following observations on the principles of the manufacture of porcelain and earthenware.

Observations by Vauquelin.

Component parts of porcelain and pottery ware.

According to this celebrated chemist, four things may occasion differences in the qualities of earthenware; first, the nature or composition of the matter; second, the mode of preparation; third, the dimensions given to the vessels; fourth, the baking to which they are subjected. By composition of the matter, the author understands the nature and proportions of the elements of which it is formed. These elements in the greater part of earthen ware, either valuable or common, are silex, argil, lime, and sometimes a little oxide of iron. Hence it is evident that it is not so much by the diversity of the elements that good earthenware differs from bad, as by the proportion in which they are united. Silex or quartz makes always two-thirds at least of earthenware; argil or pure clay, from a fifth to a third; lime from 5 to 20 parts in the hundred; and iron from 0 to 12 or 15 parts in the hundred. Silex gives hardness, infusibility, and unalterability; argil makes the paste pliable, and renders it fit to be kneaded, moulded, and turned at pleasure. It possesses, at the same time, the property of being partially fused by the heat which unites its parts with those of the silex; but it must not be too abundant, or it would render the earthen ware too fusible, and too brittle to be used over the fire.

Hitherto it has not been proved by experience that lime is necessary in the composition of pottery; and if traces of it are constantly found in that substance, it is because it is always mixed with the other earths, from which the washings and other manipulations have not been able to separate it. When this earth, however, does not exceed five or six parts in a hundred, it appears that it is not hurtful to the quality of the pottery; but if more abundant it renders it too fusible. The oxide of iron, besides the inconvenience of communicating a red or brown colour, according to the degree of baking, to the vessels in which it forms a part, has the property of rendering them fusible, and even in a greater degree than lime.

Mode of preparation.

As some kinds of pottery are destined to melt very penetrating substances, such as salts, metallic oxides, glass, &c. they require a fine kind of paste, which is obtained only by reducing the earths employed to very minute particles. Others destined for melting metals, and substances not very penetrating, and which must be able to support, without breaking, a sudden transition from great heat to great cold, require for their fabrication a mixture of calcined argil with raw argil. By these means you obtain pottery, the coarse paste of which resembles *brèche*, or small-grained pudding-stone, and which can endure sudden changes of temperature.

Baking.

The baking of pottery is likewise an object of great importance. The heat must be capable of expelling humidity, and agglutinating the parts which enter into the composition of the paste, but not strong enough to produce fusion; which, if too far advanced, gives to pottery a homogeneousness that renders it brittle. The same effect takes place in regard to the fine pottery, because the very minute division given to the earths reduces them nearly to the same state as if this matter had been fused. This is the reason why porcelain strongly baked is more or less brittle, and cannot easily endure alternations of temperature. Hence coarse porcelain, in the composition of which a certain quantity of calcined argil is employed, porcelain retorts, crucibles, tubes, and common pottery, the paste of which is coarse, are much less brittle than dishes and saucers formed of the same substance, but ground with more labour.

Dimensions of the different parts of vessels.

The general and respective dimensions of the different parts of vessels of earthenware, have also considerable influence on their capability to stand the fire. In some cases the glazing or covering, especially when too thick, and of a nature different from the body of the pottery, also renders them liable to break. Thus, in making some kinds of pottery, it is always essential, first, to follow the best proportion in the principles; secondly, to give to the particles of the paste, by grinding, a minuteness suited to the purpose for which it is intended, and to all the parts the same dimensions as far as possible; thirdly, to carry the baking to the highest degree that the matter can bear without being fused; and fourthly, to apply the glazing in thin layers, the fusibility of which ought to approach as near as possible to that of the matter, in order that it may be more intimately united.

M. Vauquelin, being persuaded that the quality of good pottery depends chiefly on using proper proportions of the earthy matter, thought it might be of importance to those engaged in this branch of manufacture, to make known the analysis of different natural clays employed for this pur-

Porcelain.

pose, and of pottery produced by some of them, in order that, when a new earth is discovered, it may be known by a simple analysis whether it will be proper for the same object, and to what kind of pottery already known it bears the greatest resemblance.

	Hessian Crucibles.	Argil of Dreux.	Porcelain Capsules.	Wedgwood's Pyrometers.
Silex.....	69	43.5	61	64.2
Argil.....	21.5	33.2	28	25
Lime.....	1	3.5	6	6
Oxide of Iron.....	8	1.	0.5	0.2
Water.....	...	18.	...	6.2

Raw kaolin 100 parts; silex, 74; argil, 16.5; lime, 2; water, 7. A hundred parts of this earth gave eight of alum, after being treated with the sulphuric acid.

Washed kaolin, 100 parts; silex, 55; argil, 27; lime, 2; iron, 0.5; water, 14. This kaolin, treated with the sulphuric acid, gave about 45 or 50 per cent. of alum.

Petuntze. Silex, 74; argil, 14.5; lime, 5.5; loss, 6. A hundred parts of this substance, treated with the sulphuric acid, gave seven or eight parts of alum. But this quantity does not equal the loss sustained.

Porcelain of retorts. Silex, 64; argil, 28.8; lime, 4.55; iron, 0.50; loss, 2.77. Treated with the sulphuric acid this porcelain gave no alum.

Porous ware.

There is a kind of earthen vessels, called *Alcarrezes*, which are used in Spain for cooling the water intended to be drunk. These vessels consist of 60 parts of calcareous earth, mixed with alumina and a little oxide of iron, and 36¼ of siliceous earth, also mixed with alumina and the same oxide. The quantity of iron may be estimated at almost one hundredth part of the whole. This earth is first kneaded into a tough paste, being for that purpose previously diluted with water; then formed into a cake of about six inches in thickness, and left in that state until it begin to crack. It is then kneaded with the feet, the workman gradually adding to it a quantity of sea-salt, in the proportion of seven pounds to a hundred and fifty; after which it is applied to the lathe, and baked in any kind of furnace used by potters. The alcarrezes, however, are only about half as much baked as the better kinds of common earthenware; and being exceedingly porous, water oozes through them on all sides. Hence the air which comes in contact with it, by causing it to evaporate, carries off the caloric contained in the water in the vessel, which is thus rendered remarkably cool.

Observations of Brongniart on the Colours used for Enamelling.

Enamel of the ancients.

The art of employing metallic oxides for colouring by fusion different vitreous matters, is of very great antiquity. Every body knows that the ancients manufactured coloured glass and enamel, and that this art was practised in particular by the Egyptians, the first people who in this manner imitated precious stones. The practice of this art in modern times has been carried to a high degree of perfection; but the theory has been neglected. It is almost the only one of the chemical arts in which no attempt has yet been made to apply the new principles of that science. It is well known that all vitrifiable colours have for their basis metallic oxides; but all the metallic oxides are not proper for this purpose; besides, as they are not vitrifiable by themselves, they can scarcely ever be employed alone.

Metallic oxides employed as colours for porcelain.

Highly volatile oxides, and those which adhere little to the great quantity of oxygen they contain, either cannot be employed in any manner, as the oxide of mercury and that of arsenic, or are employed only as agents. The colour they present cannot be depended on, since they must lose it in the slightest heat by losing a part of their oxygen. Such are the puce-coloured and red oxides of lead, the yellow oxides of gold, and some others. Oxides in which the proportions of oxygen are susceptible of varying with too much facility, are rarely employed. The oxide of iron, though black, is never employed for producing that colour; and the green oxide of copper is, under many circumstances, very uncertain. We have said that oxides alone are not susceptible of fusion. However, as they are destined to be applied to thin strata upon vitrifiable substances, they may be attached to them by a violent heat. But, excepting the oxides of lead and bismuth, they would give only dull colours. The violent heat, often necessary to fix them, would change or totally destroy the colours. A flux then is added to all metallic oxides.

This flux is glass, lead, and silex; glass of borax, or a mixture of both. Its general effect is to give splendour to the colours after their fusion; to fix them upon the article which is painted, by promoting more or less the softening of its surface; to envelope the metallic oxides, and to preserve their colour, by sheltering them from the contact of the air; in a word, to facilitate the fusion of the colour at a low temperature not capable of destroying it.

The substances to which they are applied.

But we shall speak here only of the application of metallic colours to vitreous bodies, or to vitreous surfaces. These bodies may be divided into three classes, very distinct by the nature of the substances which compose them, the effects produced on them by the colours, and the changes they experience. These crusts are, first, enamel, soft porcelain, and all crusts, enamels, or glass, that contain lead in a notable quantity; secondly, hard porcelain, or porcelain which has a crust of feldspar; thirdly, glass in the composition of which no lead enters, such as common window-glass. We shall here examine in succession the principles of the composition of these colours, and the general phenomena they exhibit on these three kinds of bodies.

It is well known that enamel is glass rendered opaque by the oxide of tin, and exceedingly fusible by the oxide of lead. It is the oxide of lead, in particular, contained in it, that gives it properties very different from those of the other excipients of metallic colours. Thus all glass and glazing that contain lead, will participate in the properties of enamel; and what we shall say of one may be applied to the rest with very trifling differences. Such are the white and transparent glazing of stoneware, and the glazing of porcelain called *soft glazing*.

Flux for soft porcelain colours

Enamel or soft porcelain colours require much less flux than others, because the glass upon which they are applied becomes sufficiently soft to be penetrated by them. This flux may be either glass of lead and pure silex, called *rocaille*, or the same glass mixed with borax. Montamy asserts that glass of lead ought to be banished from among the enamel fluxes; and he employs only borax. He then dilutes his colours in a volatile oil. On the other hand, the painters of the manufactory of Sèvres employ only colours without borax, because they dilute them in gum; and borax does not dilute well in that substance. Brogniart found that both methods were equally good; and it is certain that Montamy was wrong to exclude fluxes of lead, since they are daily employed without any inconvenience, and as they even render the application of colours easier.

We have said that in the baking of these colours, the crust, softened by the fire, suffers itself to be easily penetrated by them. This is the first cause of the change which they experience. By mixing with the crust they become weaker, and the first heat changes a figure which appeared to be finished into a very light sketch.

The two principal causes of the changes which colours on enamel and soft porcelain are susceptible of experiencing do not depend in any manner upon the composition of these colours, but upon the nature of the glass to which they are applied. It follows from what has been said, that paint-

Porcelain. ing on soft porcelain has need of being several times retouched, and of several heats, in order that it may be carried to the necessary degree of strength. These paintings have always a certain faintness; but they are constantly more brilliant, and they never are attended with the inconvenience of detaching themselves in scales.

Colours applied to hard porcelain, and to glass. Hard porcelain, according to the division which Brogniart established, is the second sort of excipient of metallic colours. This porcelain, as is well known, has for its base a very white clay called *kaolin*, mixed with a siliceous and calcareous flux, and for its covering feldspar fused without an atom of lead. The same porcelain, which is that of Saxony, is much newer at Sèvres than the soft porcelain. The colours applied to it are of two kinds. The first, destined to represent different objects, are baked in a heat very inferior to that which is necessary for baking porcelain. They are exceedingly numerous and varied. The others, destined to be fused in the same heat as that which bakes porcelain, lay themselves flat, and are much less numerous. The colours of painting are made nearly like those destined for soft porcelain; they only contain more flux. Their flux is composed of glass of lead and borax. When porcelain is exposed to heat in order to bake the colours, the covering of feldspar dilates itself and opens its pores, but does not become soft; and as the colours do not penetrate it, they experience none of those changes which they undergo on soft porcelain. It must however be said that they lose a little of their intensity by acquiring that transparency which is given to them by fusion.

One of the greatest inconveniences of these colours, especially in the manufactory of Sèvres, is the facility with which they scale off when exposed several times in the fire. To remedy this defect without altering the quality of the paste, Brogniart was of opinion that the crust only ought to be softened by introducing into it more siliceous or calcareous flux, according to the nature of the feldspar. This method succeeded, and being employed, the colours might be exposed two or three times to the fire without scaling, if not overcharged with flux, and laid on too thick.

The third sort of excipient of vitrifiable metallic colours is glass without lead. The application of these colours to glass constitutes painting on glass; an art very much practised some centuries ago, and which was supposed to be lost because out of fashion; but it has too direct a dependence on painting in enamel and porcelain to be entirely lost.

The matters and fluxes which enter into the composition of the colours employed on glass are in general the same as those applied to porcelain. Neither of them differ except in their proportions; but there are a great number of enamel or porcelain colours which cannot be applied to glass, where they are deprived of the white ground that serves to give them relief.

Of Colours in particular.

After collecting the general phenomena exhibited by each class of vitrifiable colours, considered in regard to the body on which they are applied, we shall now make known the most interesting particular phenomena exhibited by each principal kind of colours employed upon soft porcelain and glass in a porcelain furnace.

Reds, Purples, and Violets, made from Gold.

Carmine red is obtained by the purple precipitate of cassius. It is mixed with about six parts of its flux; and this mixture is employed directly, without being fused. It is then of a dirty violet, but by baking it acquires a beautiful red carmine colour. It is, however, exceedingly delicate; but a little too much heat and carbonaceous vapours easily spoil it. On this account it is more beautiful when baked with charcoal than with wood.

This colour and the purple, which is very little different, as well as all the shades obtained from it by mixing it with other colours, really change on all porcelain and in every hand. But it is the only one which changes on hard porcelain. Its place may be supplied by a rose-colour from iron which does not change; so that by suppressing the carmine made with gold, and substituting for it the rose oxide of iron here alluded to, a palette may be exhibited, composed of colours none of which changes in a remarkable manner. This rose-coloured oxide of iron has long been known; but it was not employed on enamel, because on that substance it changed too much. As the painters on enamel, however, have become the painters on porcelain, they have preserved their ancient method. Porcelain.

It might be believed that, by first reducing to a vitreous matter the colour called *carmine* already mixed with its flux, it might be made to assume its last tint. But the heat necessary to fuse this vitreous mass destroys the red colour. Besides, it is remarked that, to obtain this colour very beautiful, it must be exposed to the fire as few times as possible. The carmine for soft porcelain is made with fulminating gold slowly decomposed, and muriate of silver; no tin enters into it, which proves that the combination of the oxide of this metal with that of gold is not necessary to the existence of the purple colour. Violet is also made with purple oxide of gold. A greater quantity of lead in the flux is what gives it this colour, which is almost the same crude or baked. These three colours totally disappear when exposed to a great porcelain heat.

Carmine and purple give us in glass only tints of a dirty violet. The violet, on the other hand, produces on glass a very beautiful effect, but it is liable to turn blue. We have not been able to discover the cause of this singular change.

Red, Rose, and Brown Colours, extracted from Iron.

These colours are made from red oxide of iron prepared with nitric acid. The oxides are further calcined by keeping them exposed to the action of heat; but if heated too much, they pass to brown. Their flux is composed of borax, sand, and minium, in small quantity.

These oxides give rose and red colours capable of supplying the place of the same colours made with oxide of gold. When properly employed upon hard porcelain, they do not change at all. We have caused roses to be painted with these colours, and found no difference between the baked flower and that not baked, except what might be expected to result from the brilliancy given to colours by fusion.

These colours may be employed indiscriminately, either previously fused or not fused. In a great heat they in part disappear, or produce a dull brick ground, which is not agreeable. The composition of them is the same both for soft porcelain and for glass. They do not change on the latter; but on soft porcelain they disappear almost entirely on the first exposure to heat, and to make any thing remain they must be employed very deep. This singular effect must be ascribed to the presence of lead in the crust or glazing. We assured ourselves of this by a very simple experiment. We placed this colour on window glass, and having exposed it to a strong baking, it did not change. We covered several parts of it with minium; and on again exposing it to the fire, the colour was totally removed in the places where the red oxide of lead had been applied. By performing this operation on a larger scale in close vessels, a large quantity of oxygen gas was disengaged.

It appears to us that the observation here referred to clearly proves the action of oxidated lead on glass as a destroyer of colour; it is seen that it does not act, as was believed, by burning the combustible bodies, which might tarnish the glass, but by dissolving, discolouring, or volatilizing with it the oxide of iron, which might alter its transparency.

Yellows.

Yellows are colours which require a great deal of care in the fabrication, on account of the lead which they contain, and which, approaching sometimes to the metallic state, produces on them dark spots. The yellows for hard and soft porcelain are the same; they are composed of the oxide of lead, white oxide of antimony, and sand.

Oxide of tin is sometimes mixed with them; and when it is required to have them more lively, and nearer the colour *du souci*, red oxide of iron is added, the too great redness of which is dissipated in the previous fusion to which they are exposed by the action of the lead contained in this yellow. These colours, when once made, never change; they disappear, however, almost entirely when exposed to a porcelain heat.

These yellows cannot be applied to glass, because they are too opaque and dirty. That employed by the old painters on glass has, on the contrary, a beautiful transparency, and is exceedingly brilliant, and of a colour which approaches near to that of gold. The processes which they gave clearly showed that silver formed part of their composition; but, when exactly followed, nothing satisfactory was obtained. M. Miraud found means to make as beautiful paintings on glass as the ancients, by employing muriate of silver, oxide of zinc, white argil, and yellow oxide of iron. These colours were applied on glass merely pounded, and without a flux. The oxide of iron brought the yellow to that colour which it ought to have after baking, and contributed with the argil and oxide of zinc to decompose the muriate of silver without deoxidating the silver. After the baking, there remained a dust which had not penetrated into the glass, and which was easily removed.

This yellow, when employed thicker, gives darker shades, and produces a russet colour.

Blues.

It is well known that blues are obtained from the oxide of cobalt. All chemists are acquainted with the preparation of them. Those of Sèvres, which are justly esteemed for their beauty, are indebted for it solely to the care employed in manufacturing them, and to the quality of the porcelain, which appears more proper for receiving them in proportion to the degree of heat which it can bear.

Respecting the oxide of cobalt, we may remark a fact which is perhaps not known to chemists; namely, its volatility in a violent heat. It is to this property that we must ascribe the bluish tint always assumed by white in the neighbourhood of the blue.

The blue of hard porcelain, destined for what is called the ground of a great heat *(les fonds au grand feu)* is fused with feldspar; that of soft porcelain has for its flux silex, potash, and lead. It is not volatilized like the preceding; but the heat which it experiences is very inferior to that of hard porcelain. These colours, when previously fused, do not change at all in the application. Blues on glass exhibit the same phenomena as those on soft porcelain.

Greens.

The greens employed in painting are made with green oxide of copper, or sometimes with a mixture of yellow or blue. They must be previously fused with their flux, otherwise they will become black; but after this first fusion they no longer change. They cannot stand a strong heat, as it would make them disappear entirely. Green grounds for a strong heat are composed with the oxides of cobalt and nickel, but a brownish green only is obtained.

Bluish greens, called *celestial blues*, which were formerly colours very much in vogue, can be applied only upon soft porcelain; on hard porcelain they consequently become scaly, because potash enters into their composition. These greens cannot be applied on glass, because they give a dirty colour. To obtain a green on glass, it is necessary to put yellow on one side, and blue, more or less pale, on the other. This colour may be also made by a mixture of blue with yellow oxide of iron.

Bistres and Russets.

These are obtained by mixtures, in different proportions, of manganese, brown oxide of copper, and oxide of iron from ombre earth. They are also previously fused with their flux, so that they do not in any manner change on soft porcelain, since lead has not the same action on oxide of manganese as on that of iron. This colour fades very speedily on glass.

Russet grounds in a great heat, known under the name of *tortoise-shell grounds*, are made in the same manner. Their flux is feldspar; and no titanium enters into their composition, though it is so stated in all printed works. Titanium was not known at the manufactory of Sèvres when Brogniart arrived there. He treated this singular metal in various ways, and never obtained any but grounds of a pale dirty yellow, and very variable in tone.

Blacks.

Blacks are the colours the most difficult to be obtained of a very beautiful hue. No metallic oxide alone gives a beautiful black. Manganese is that which approaches nearest to it. Iron gives an opaque, dull, cloudy black, which changes very easily to red; the colour-makers, therefore, to obtain a black which they could not hope for from the best theorist, have united several metallic oxides which separately do not give black, and have obtained a very beautiful colour, which, however, is liable to become scaly and dull. These oxides are those of manganese, the brown oxides of copper, and a little of the oxide of cobalt. The grey is obtained by suppressing the copper, and increasing the dose of the flux.

The manufactory of Sèvres is the only one which has hitherto produced beautiful blacks in a strong heat. This is owing rather to the quality of its paste than to any peculiar processes, since it does not conceal them. It is by darkening the blue by the oxides of manganese and iron that they are able in that manufactory to obtain very brilliant blacks.

Having here made known the principles of the fabrication of each principal colour, it may be readily conceived that by mixing these colours together all the shades possible may be obtained. It is evident also that care in the preparation, choice in the raw materials, and a just proportion of doses, must produce in the result, differences very sensible to an eye accustomed to painting. A mere knowledge of the composition of the colours does not give the talent of executing them well.

Facts relative to colours recapitulated.

From the facts above mentioned, it is therefore seen, 1st, That amongst colours generally employed on hard porcelain one only is susceptible of changing, viz. carmine, and the tints into which it enters; that its place may be supplied by the reds of iron, and that no colour then changes. 2d, That amongst the colours for soft porcelain and enamel, several change in a considerable degree. These are principally the reds of gold and iron, the yellows, the greens, and the browns. They have not been replaced by others, because this kind of painting has been almost abandoned. 3d, That several of the colours on glass change also by acquiring complete transparency. These, in particular, are the yellows and green. 4th, That it is neither by calcining the colours in a higher degree, nor previously fusing them, as supposed by some, that they are prevented from changing, since these means really alter the changing colours, and produce no effect on the rest. The change which

Porch
Poretschie.

several colours experience upon soft porcelain and upon glass does not depend on the nature of their composition, but rather on that of the body upon which they are applied.

It follows, then, that, by suppressing from the colours of hard porcelain the carmine of gold, which is by no means indispensably necessary, we shall have a series of colours which do not change, or, in other words, remain unalterable. So much for the colours employed in this manufacture. X. X.

Porism.

PORCH, in *Architecture*, a kind of vestibule supported by columns, and much used at the entrance of temples, halls, and other edifices.

A porch, in ancient architecture, was a vestibule, or a disposition of insulated columns usually crowned with a pediment, forming a covert place before the principal door of a temple or court of justice. When a porch had four columns in front, it was called a tetrastyle; when six, a hexastyle; when eight, an octostyle, and so on.

PORCH, in Greek στοα, a public portico in Athens, adorned with the pictures of Polygnotus and other eminent painters. It was in this portico that Zeno the philosopher taught; and hence his followers were called Stoics.

PORCHESTER, a village of the county of Hants and in the hundred of Portsdown. It is on the north side of Portsmouth harbour, and is remarkable for its extensive and ancient castle, in which, during the war, some thousands of French prisoners were confined. The walls inclose a square of four acres. It formerly belonged to the crown, and was settled by Edward IV. on his queen Margaret. It is now private property, and during the war was rented by the government, and converted into a prison. Since the peace, the population has somewhat declined, having been in 1801, 917; in 1811, 818; in 1821, 757; and in 1831, 739.

PORCO, a province of Bolivia in South America, to the west of the city of Potosi. The region is elevated, and the climate is consequently cold, so that although in the valleys the soil is productive, there is a scarcity of grains and fruit. It is properly a pastoral country, and here are reared vast numbers of sheep, and also vicuñas and guanacos, native sheep. The mountain of Porco in this province is celebrated for its silver mines. It was the first worked by the Spaniards after the conquest; and before that epoch it had been the source whence the Incas of Peru obtained their chief supplies of the precious metal. The original mine is still wrought, but, like most others in this quarter, without much vigour. Porco, the capital of the province, is a small town with but few inhabitants. The population of the province is estimated at above one hundred thousand.

PORCU, a town on the sea-coast of Hindustan, situated in the province of Travancore. It is populous, and carries on a considerable trade. The adjacent country is fertile, and produces abundance of rice. The inhabitants consist of Mahommedan, Hindu, and Christian merchants. The Dutch had formerly a factory here for procuring cargoes of pepper. Long. 76. 24. E. Lat. 9. 23. N.

PORDENONE, a city of Austrian Italy, in the province of Milan, and delegation of Belluno. It stands on the river Roncello, and contains 650 houses, with 4230 inhabitants, who are chiefly employed in making linen goods and paper. Lat. 45. 56. 42. Long. 12. 34. 54. E.

PORETSCHIE, a city of the Russian empire, in the province of Smolensko, the capital of a circle of the same name. It is situated on the river Kasplea, which is navigable thus far, but no farther. It is 478 miles from St. Petersburg, and favourably situated as a depôt for the trade between Smolensko and Riga. It contains three churches, 580 houses, and 5900 inhabitants, with large storehouses. Lat. 55. 10. Long. 31. 25. E.

PORISM, in *Geometry*, is a name given by the ancient geometers to two classes of mathematical propositions. Euclid applies this name to propositions, which are involved in others which he is professedly investigating, and which, although they do not form his principal object, are obtained along with it, as is expressed by their name *porismata*, or acquisitions. Such propositions are now called *corollaries*. But he gives the same name, by way of eminence, to a particular class of propositions which he collected in the course of his researches, and selected from amongst many others, on account of their great subserviency to the business of geometrical investigation in general. These propositions were so named by him, either from the way in which he discovered them, that is to say, whilst he was investigating something else, so that they might be considered as *gains* or *acquisitions*, or from their utility as steps in the investigation. In this sense they are *porismata*; for ποριζω (from which, according to Proclus, the term is derived) signifies both to investigate and to acquire by investigation. These propositions formed a collection in three books, which was familiarly known to the ancient geometers by the name of Euclid's *porisms*; and Pappus of Alexandria says, that it was a most ingenious collection of many things conducive to the analysis or solution of the most difficult problems, and which afforded great delight to those who were able to understand and investigate them.

Unfortunately for mathematical science, this valuable collection is now lost, and it still remains a doubtful question in what manner the ancients conducted their researches upon this curious subject. We have, however, reason to believe that their method was both comprehensive and excellent; for their analysis led them to many profound discoveries, and was restricted by the severest logic. The only account we have of this class of geometrical propositions, is in a fragment of Pappus, in which he attempts a general description of them, as a set of mathematical propositions distinguishable in kind from all others; but of this description nothing remains, except a criticism on a definition of the term given by some geometers, namely, "A Porism is that which is deficient in hypothesis from a local theorem," and which he finds fault with, as defining the porisms only by an accidental circumstance. Pappus also gives an account of Euclid's porisms; but the enunciations are so extremely defective, at the same time that they refer to a figure now lost, that Dr. Halley confesses the fragment in question to be beyond his comprehension.

The high encomiums pronounced by Pappus on these propositions have excited the curiosity of the greatest geometers of modern times, who have attempted to discover their nature and the manner of investigating them. Fermat gave a few propositions, which have been published in his *Opera* (Tolosæ, 1679), and Bullialdus, in a tract entitled *Exercitationes Geometricæ Tres* (Paris, 1657), attempted the same thing, but with less success. Albert Girard, at a still earlier period, announced that he had restored the whole of the three books of Euclid, but it does not appear that this part of his works was ever published.[1]

At length Dr. Simson, Professor of Mathematics in the University of Glasgow, was so fortunate as to succeed in

[1] In his *Trigonometry*, published at the Hague in 1629, after enumerating the forms of certain rectilinear figures, Girard adds, "Le tout, quand il n'y a que deux lignes qui passent par un point, comme jadis estoyent les Porismes d'Euclid, qui sont perdus, lesquelles J'espère de mettre bientot en lumière, les ayant restituez, il y a quelques années en ça." A similar announcement is also made by him in his edition of the works of Stevinus (Lugduni. Batav. 1634. p. 459.) Having mentioned that Euclid rarely employs a compound ratio, he adds, "Mais il est à estimer qu'il en a plus escrit en ses trois livres de Porismes qui sont perdus, lesquelles, Dieu aidant, J'espère de mettre en lumière, les ayant inventez de nouveau." (See the preface to Simson's *Tractatus de Porismatibus*, in his *Opera Reliqua*.)

Porism. restoring the porisms of Euclid. In the preface to his treatise *De Porismatibus*, he gives the following account of his progress and of the obstacles he encountered: " Postquam vero apud Pappum legeram Porismata Euclidis Collectionem fuisse artificiosissimam multarum rerum, quæ spectant ad analysin difficiliorum et generalium problematum, magno desiderio tenebar, aliquid de iis cognoscendi; quare sæpius et multis variisque viis tum Pappi propositionem generalem, mancam et imperfectum, tum primum lib. 1. Porisma, quod, ut dictum fuit, solum ex omnibus in tribus libris integrum adhuc manet, intelligere et restituere conabar; frustra tamen, nihil enim proficiebam. Cumque cogitationes de hac re multum mihi temporis consumpserint, atque tandem molestæ admodum evaserint, firmiter animum induxi haec nunquam in posterum investigare; præsertim cum optimus Geometra Halleius spem omnem de iis intelligendis abjecisset. Unde quoties menti occurrebant, toties eas arcebam. Postea tamen accidit ut improvidum et propositi immemorem invaserint, meque detinuerint donec tandem lux quædam effulserit quae spem mihi faciebat inveniendi saltem Pappi propositionem generalem, quam quidem multa investigatione tandem restitui."

Dr. Simson's *Restoration* has every appearance of being just. All the lemmas which Pappus has given for the better understanding of Euclid's propositions are equally applicable to those of Dr. Simson, which are found to differ from local theorems precisely as Pappus affirms those of Euclid to have done. They require a particular mode of analysis, and are of immense service in geometrical investiga tion.

Whilst Dr. Simson was employed in this inquiry, he carried on a correspondence upon the subject with the late Dr. Matthew Stewart, Professor of Mathematics in the University of Edinburgh; who, besides entering into Dr. Simson's views, and communicating to him many curious porisms, pursued the same subject in a new and very different direction. He published the result of his inquiries in 1746, under the title of *General Theorems*, not wishing to give them any other name, lest he might appear to anticipate the labours of his friend and former preceptor. The greater part of the propositions contained in that work are porisms, but without demonstration; and those who wish to investigate one of the most curious subjects in geometry, will there find abundance of materials, and an ample field for discussion.

Dr. Simson defines a porism to be " a proposition, in which it is proposed to demonstrate, that one or more things are given, between which, and every one of innumerable other things not given, but assumed according to a given law, a certain relation, described in the proposition, is to be shewn to take place."

This definition is somewhat obscure, but will be plainer if expressed thus: " A porism is a proposition affirming the possibility of finding such conditions as will render a certain problem indeterminate, or capable of innumerable solutions." This definition agrees with Pappus's idea of these propositions, as far at least as they can be understood from the fragment already mentioned; for the propositions here defined, like those which he describes, are, strictly speaking, neither theorems nor problems, but of an intermediate nature between both. They neither simply enunciate a truth to be demonstrated, nor propose a question to be resolved, but are affirmations of a truth in which the determination of an unknown quantity is involved. In as far, therefore, as they assert that a certain problem may become indeterminate, they are of the nature of theorems; and, in as far as they seek to discover the condition by which that is brought about, they are of the nature of problems.

In order to give our readers a clear idea of the subject of porisms, we shall consider them in the way in which it is probable they occurred to the ancient geometers in the course of their researches. This will at the same time shew the nature of the analysis peculiar to them, and their great use in the solution of problems. Porism.

It appears to be certain, that it has been the solution of problems which, in all states of the mathematical sciences, has led to the discovery of geometrical truths. The first mathematical inquiries, in particular, must have occurred in the form of questions, where something was given, and something required to be done; and by the reasoning necessary to answer these questions, or to discover the relation between the things given and those to be found, many truths were suggested, which came afterwards to be the subject of separate demonstrations. The number of these was the greater, because the ancient geometers always undertook the solution of problems, with a scrupulous and minute attention, insomuch that they would scarcely suffer any of the collateral truths to escape their observation.

Now, as this cautious manner of proceeding was not better calculated to avoid error than to lay hold of every collateral truth connected with the main object of inquiry, these geometers soon perceived, that there were many problems which in certain cases would admit of no solution whatever, in consequence of a particular relation existing amongst the quantities which were given. Such problems were said to become impossible; and it was soon perceived, that this always happened when one of the conditions of the problem was inconsistent with the rest. Thus, when it was required to divide a line, so that the rectangle contained by its segments might be equal to a given space, it was found that this was possible only when the given space was less than the square of half the line; for when it was otherwise, the two conditions defining, the one the magnitude of the line, and the other the rectangle of its segments, were inconsistent with each other. Such cases would occur in the solution of the most simple problems; but if they were more complicated, it must have been remarked, that the constructions would sometimes fail, for a reason directly contrary to that just now assigned. Cases would occur, where the lines, which by their intersection were to determine the thing sought, instead of intersecting each other as they did commonly, or of not meeting at all, as in the above mentioned case of impossibility, would coincide with one another entirely, and of course leave the problem unresolved. It would appear to geometers upon a little reflection, that since, in the case of determinate problems, the thing required was determined by the intersection of the two lines already mentioned, that is, by the points common to both; so in the case of their coincidence, as all their parts were in common, every one of these points must give a solution, or, in other words, the solutions must be indefinite in number.

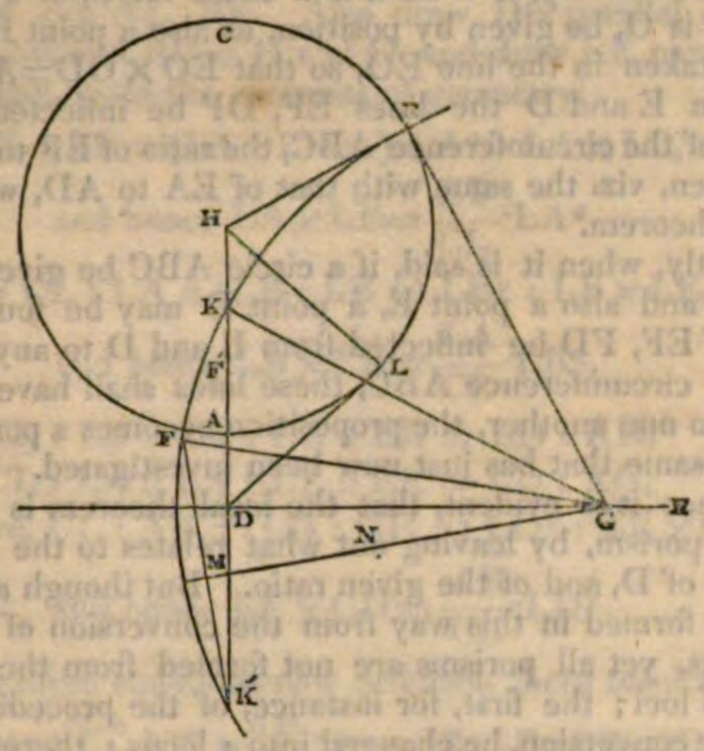
Upon inquiry, it would be found that this proceeded from some condition of the problem having been involved in another, so that, in fact, the two formed but one, and thus there was not a sufficient number of independent conditions to limit the problem to a single or to any determinate number of solutions. It would soon be perceived, that these cases formed very curious propositions of an intermediate nature between problems and theorems; and that they admitted of being enunciated in a manner peculiarly elegant and concise. It was to such propositions that the ancients gave the name of *porisms*.

This deduction requires to be illustrated by an example. Suppose, therefore, that it were required to resolve the following problem. A circle ABC, (fig. 1), a straight line DE, and a point F, being given in position, to find a point G in the straight line DE such, that GF, the line drawn from it to the given point, shall be equal to GB, the line drawn from it touching the given circle.

Suppose G to be found, and GB to be drawn touching the given circle ABC in B, let H be its centre, join HB, and let HD be perpendicular to DE. From D draw DL,

Porism.

Fig. 1.



touching the circle ABC in L, and join HL; also from the centre G, with the distance GB or GF, describe the circle BKF, meeting HD in the points K and K′. It is evident that HD and DL are given in position and magnitude: also because GB touches the circle ABC, HBG is a right angle; and since G is the centre of the circle BKF, HB touches that circle, and consequently HB^2 or $HL^2 = KH \times HK'$; but because KK′ is bisected in D, $KH \times HK' + DK^2 = DH^2$, therefore $HL^2 + DK^2 = DH^2$. But $HL^2 + LD^2 = DH^2$, therefore $DK^2 = DL^2$ and DK = DL. But DL is given in magnitude, and consequently K is a given point. For the same reason K′ is a given point, therefore the point F being given in position, the circle KFK′ is given in position. The point G, which is its centre, is therefore given in position, which was to be found. Hence this construction:

Having drawn HD perpendicular to DE, and DL touching the circle ABC, make DK and DK′ each equal to DL, and find G the centre of the circle described through the points K′FK; that is, let FK′ be joined and bisected at right angles by MN, which meets DE in G, G will be the point required; or it will be such a point, that if GB be drawn touching the circle ABC, and GF to the given point, GB is equal to GF.

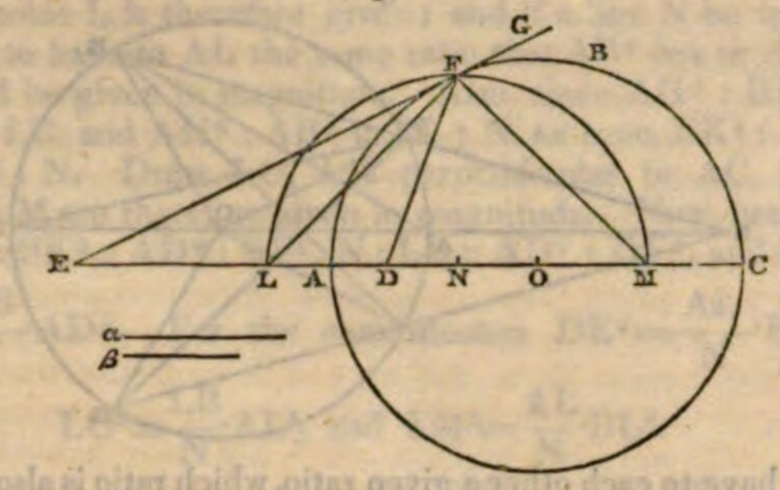
The synthetical demonstration is easily derived from the preceding analysis; but it must be remarked, that in some cases this construction fails. For, first, if F fall anywhere in DH, as at F′, the line MN becomes parallel to DE, and the point G is nowhere to be found; or, in other words, it is at an infinite distance from D. This is true in general; but if the given point F coincide with K, then MN evidently coincides with DE; so that, agreeable to a remark already made, every point of the line DE may be taken for G, and will satisfy the conditions of the problem; that is to say, GB will be equal to GK, wherever the point G is taken in the line DE: the same is true if F coincide with K′. Thus we have an instance of a problem, and that too a very simple one, which, in general, admits but of one solution; but which, in one particular case, when a certain relation takes place among the things given, becomes indefinite, and admits of innumerable solutions. The proposition which results from this case of the problem is a porism, and may be thus enunciated:

"A circle ABC being given by position, and also a straight line DE, which does not cut the circle, a point K may be found, such, that if G be any point whatever in DE, the straight line drawn from G to the point K shall be equal to the straight line drawn from G touching the given circle ABC."

The problem which follows, appears to have led to the discovery of many porisms.

A circle ABC (fig. 2), and two points D, E, in a diameter

Fig. 2.



of it being given, to find a point F in the circumference of the given circle, from which, if straight lines be drawn to the given points E, D, these straight lines shall have to one another the given ratio of α to β, which is supposed to be that of a greater to a less. Suppose the problem resolved, and that F is found, so that FE has to FD the given ratio of α to β; produce EF towards G, bisect the angle EFD by FL, and DFG by FM: therefore EL : LD :: EF : FD, that is in a given ratio, and since ED is given, each of the segments EL, LD, is given, and the point L is also given; again, because DFG is bisected by FM, EM : MD :: EF : FD, that is, in a given ratio, and therefore M is given. Since DFL is half of DFE, and DFM half of DFG, therefore LFM is half of (DFE + DFB), that is, the half of two right angles, therefore LFM is a right angle; and since the points L, M, are given, the point F is in the circumference of a circle described upon LM as a diameter, and therefore given in position. Now the point F is also in the circumference of the given circle ABC, therefore it is in the intersection of the two given circumferences, and therefore is found. Hence this construction: Divide ED in L, so that EL may be to LD in the given ratio of α to β, and produce ED also to M, so that EM may be to MD in the same given ratio of α to β; bisect LM in N, and from the centre N with the distance NL, describe the semicircle LFM; and the point F, in which it intersects the circle ABC, is the point required.

The synthetical demonstration is easily derived from the preceding analysis. It must, however, be remarked, that the construction fails when the circle LFM falls either wholly within or wholly without the circle ABC, so that the circumferences do not intersect; and in these cases the problem cannot be solved. It is also obvious that the construction will fail in another case, viz. when the two circumferences LFM, ABC, entirely coincide. In this case, it is farther evident, that every point in the circumference ABC will answer the conditions of the problem, which is therefore capable of numberless solutions, and may, as in the former instance, be converted into a porism. We are now to inquire, therefore, in what circumstances the point L will coincide with A, and also the point M with C, and of consequence the circumference LFM with ABC. If we suppose that they coincide, EA : AD :: α : β :: EC : CD, and EA : EC :: AD · CD, or by conversion, EA : AC :: AD : CD—AD :: AD : 2DO, O being the centre of the circle ABC; therefore, also, EA : AO :: AD : DO, and by compositition, EO : AO :: AO : DO, therefore $EO \times OD = AO^2$. Hence, if the given points E and D (fig. 3), be so situated that $EO \times OD = AO^2$, and at the same time $\alpha : \beta$ :: EA : AD :: EC : CD, the problem admits of numberless solutions; and if either of the points D or E be given, the other point, and also the ratio which will render the problem indeterminate, may be found. Hence we have this porism:

"A circle ABC, and also a point D being given, another point E may be found, such that the two lines inflected from these points to any point in the circumference ABC,

Porism. nor any other than a right angle. The conclusion that is here drawn immediately from the indetermination of LD would be deduced, according to Dr. Simson's method, by assuming another point D′ any how, and from the supposition that $GD'^2 - GL^2 : LD'^2 :: GD^2 - GL^2 : LD^2$, it would easily appear that GLD must be a right angle, and the ratio that of equality.

These porisms facilitate the solution of the general problems from which they are derived. For example, let three straight lines AB, AC, BC, (fig. 5), be given in position, and also a point R, to find a point D in one of the given lines, so that DE and DF being drawn perpendicular to BC, AC, and DR, joined; DE^2+DF^2 may have to DR^2 a given ratio. It is plain, that having found G, the problem would be nothing more than to find D, such that the ratio of GD^2 to DR^2, and therefore that of GD to DR, might be given, from which it would follow, that the point D is in the circumference of a given circle, as is well known to geometers.

The same porism also assists in the solution of another problem. For if it were required to find D such that $DE^2 + DF^2$ might be a given space; having found G, DG^2 would have to DE^2+DF^2 a given ratio, and DG would therefore be given; whence the solution is obvious.

The connection of this porism with the impossible case of the problem is evident; the point L being that from which, if perpendiculars be drawn to AC and CB, the sum of their squares is the least possible. For since $DF^2 + DE^2 : DG^2 :: LO^2+LM^2 : LG^2$; and since LG is less than DG, LO^2+LM^2 must be less than DF^2+DE^2.

It is evident from what has now appeared, that in some instances at least there is a close connection between these propositions and the *maxima* or *minima*, and of consequence the impossible cases of problems. The nature of this connection requires to be farther investigated, and is the more interesting because the transition from the indefinite to the impossible case seems to be made with wonderful rapidity. Thus in the first proposition, though there be not properly speaking an impossible case, but only one where the point to be found goes off *in infinitum*, it may be remarked, that if the given point F (fig. 1), be anywhere out of the line HD, the problem of drawing GB equal to GF is always possible, and admits of just one solution; but if F be in DH, the problem admits of no solution at all, the point being then at an infinite distance, and therefore impossible to be assigned. There is, however, this exception, that if the given point be at K in this same line, DH is determined by making DK equal to DL. Then every point in the line DE gives a solution, and may be taken for the point G. Here therefore the case of numberless solutions, and of no solution at all, are as it were *conterminal*, and so close to one another, that if the given point be at K the problem is indefinite; but if it remove ever so little from K, remaining at the same time in the line DH, the problem cannot be resolved. This affinity might have been determined *a priori;* for, as we have seen, it is a general principle, that a problem is converted into a porism when one or when two of the conditions of it necessarily involve in them some one of the rest. Suppose, then, that two of the conditions are exactly in that state which determines the third; then whilst they remain fixed or given, should that third one vary or differ ever so little from the state required by the other two, a contradiction will ensue. Therefore if, in the hypothesis of a problem, the conditions be so related to one another as to render it indeterminate, a porism is produced; but if, of the conditions thus related to one another, some one be supposed to vary, whilst the others continue the same, an absurdity follows, and the problem becomes impossible. *Wherever, therefore, any problem admits both of an indeterminate and an impossible case, it is certain, that these cases are nearly related to one another, and that some of the conditions by which they are produced are common to both.* Porism.

It is supposed above, that *two* of the conditions of a problem involve in them a third; and wherever that happens, the conclusion which has been deduced will invariably take place. But a porism may in some cases be so simple as to arise from the mere coincidence of *one* condition with another, though in no case whatever can any inconsistency take place between them. There are, however, comparatively few porisms so simple in their origin, or that arise from problems where the conditions are but little complicated; for it usually happens that a problem which can become indefinite may also become impossible; and if so, the connection already explained never fails to take place.

Another species of impossibility may frequently arise from the porismatic case of a problem which will affect in some measure the application of geometry to astronomy, or any of the sciences depending upon experiment or observation. For when a problem is to be resolved by means of data furnished by experiment or observation, the first thing to be considered is, whether the data so obtained be sufficient for determining the thing sought; and in this a very erroneous judgment may be formed, if we rest satisfied with a general view of the subject. For though the problem may in general be resolved from the data with which we are provided, yet these data may be so related to one another in the case under consideration, that the problem will become indeterminate, and instead of one solution will admit of an indefinite number. This we have already found to be the case in the foregoing propositions. Such cases may not indeed occur in any of the practical applications of geometry; but there is one of the same kind which has actually occurred in astronomy. Sir Isaac Newton, in his *Principia*, has considered a small part of the orbit of a comet as a straight line described with an uniform motion. From this hypothesis, by means of four observations made at proper intervals of time, the determination of the path of the comet is reduced to this geometrical problem. Four straight lines being in position, it is required to draw a fifth line across them, so as to be cut by them into three parts, having given ratios to one another. Now this problem had been constructed by Dr. Wallis and Sir Cristopher Wren, and also in three different ways by Sir Isaac himself in different parts of his works; yet none of these geometers observed that there was a particular situation of the lines in which the problem admitted of innumerable solutions; and this happens to be the very case in which the problem is applicable to the determination of the comet's path, as was first discovered by Boscovich, who was led to it by finding, that in this way he could never determine the path of a comet with any degree of certainty.

The preceding account of this interesting branch of the ancient geometry, is taken from a very elegant and elaborate paper, *On the Origin and Investigation of Porisms*, by the late Professor Playfair, published in the third volume of the Transactions of the Royal Society of Edinburgh, and also in his collected *Works*, (vol. iii. p. 178.) For further particulars on the subject, the reader may consult the original paper of Professor Playfair; Dr. Simson's treatise, *De Porismatibus*, contained in his *Opera Reliqua;* a paper in the fourth volume of the Edinburgh Transactions, by Professor Wallace, entitled, *Some Geometrical Porisms, with examples of their application to the Solution of Problems;* Dr. Traill's *Account of the Life and Writings of Robert Simson, M.D;* and Professor Leslie's *Geometrical Analysis.* At the end of Dr. Stewart's *General Theorems*, above mentioned, five very remarkable porisms are enunciated, the demonstration of the first of which is given in Leybourn's *Mathematical Repository*, (vol. i.) and of the remaining four in the fifth volume of the same work published

Porson. December 1759, was the son of Mr. Huggin Porson, parish clerk of East Ruston, near North Walsham, in Norfolk.

His father taught him, in his childhood, to practise all the common rules of arithmetic by memory only; and, before he was nine years old, he had learned to extract the cube root in this manner. At the same time, for teaching him to read and write, he employed the method which has since been generally introduced in the schools of mutual instruction, making him draw the letters with chalk or on sand; and the neatness and accuracy of his hand-writing, for which he was distinguished through life, may be considered as bearing ample testimony to his father's ingenuity and success.

At the age of nine he was sent to a village school, kept by a Mr. Summers; but his father still made him repeat by heart in the evening the whole of the lessons of the day; and there seems to be sufficient evidence for considering this practice of exercising the memory continually, in very early life, as the best, if not the only method of cultivating, if not of producing great talent. For though a strong memory by no means constitutes talent, yet its possession is almost a necessary condition for the successful exertion of talent in general; and, indeed, it is very possible that the other faculties of the mind may be strengthened by the early cultivation of this one. It is remarkable that Wallis, who was as deservedly celebrated in his day as Porson, for his unerring sagacity, had also a singular facility of retaining numbers and calculations in his memory, but without having taken any particular pains to acquire the habit. Mr. Hewitt, the vicar of the parish of East Ruston, hearing of young Porson's uncommon capacity, undertook to instruct both him and his brother Thomas in classical literature; and when he was about fifteen, Mr. Norris, a wealthy and respectable gentleman of the neighbourhood, having ascertained the truth of the reports that he heard of him, resolved to be at the expense of sending him to Eton. Without this assistance it would have been impossible for Porson to have acquired great excellence in any intellectual pursuit; for his father's situation in life was not such as to exempt his son even from the subordinate occupations of the country. He went out gleaning, in the autumn, with a Horace in his pocket; and he had learned by experience to appreciate the mechanical labours of Penelope, before he was much acquainted with the wisdom and wanderings of Ulysses.

At Eton, his talents procured him the friendship and admiration of the seniors amongst his schoolfellows, and, upon the unfortunate death of his first patron, Mr. Norris, he found a number of liberal contributors, who stepped forward to supply the deficiency; but by far the most active of them was Sir George Baker, then President of the Royal College of Physicians, a man as much distinguished by his own classical taste and acquirements, as by his laudable disposition to cherish learning in others. He received the boy into his house for a vacation, and undertook, at the request of a relation of Mr. Norris, the disagreeable task of receiving, in small sums, as much as was sufficient to purchase an income of L.80 a-year, for a few years, in the short annuities, which served, with great economy, to enable him to remain at Eton. This favour appears to have been too great to be properly acknowledged, or perhaps even duly appreciated, by its object, who only after many years paid Sir George the tardy compliment of a dedication, not, however, of an edition, but of a handsome copy of a single play of Euripides. In his own opinion, Porson learned little at Eton besides the quantity of syllables, being able to repeat by heart before he went there the principal part of the authors that he had to read; that is, almost the whole of Horace and Virgil, the *Iliad*, and many parts of Cicero, Livy, and the *Odyssey*. A story is accordingly told of his book having been changed by one of his schoolfellows in joke, when he was going up to a lesson in Horace, and of his having read and translated what was required of him, without at all betraying the change to his master. At the same time, the emulation of a public school must have been a great advantage to him, as affording him a motive for exertion in his exercises, whether they were to be called his own, or to be written for other boys. It was a copy of Toup's Longinus, presented to him as a reward for a good exercise, that first gave him a decided inclination for the pursuit of critical researches; but he always considered Bentley and Dawes as his great masters in criticism. Porson.

In 1777 he was sent to Trinity College, Cambridge, and at first he began to apply more particularly to the mathematics, which had been the favourite study of his boyhood, and in which, as he himself remarked, his proficiency first brought him into a certain degree of public notice. He was, however, soon diverted from this pursuit, although he attained a place amongst the *senior optimes* of his year. But he was in fact more calculated for classical than for mathematical excellence. His memory would have been in a great measure thrown away, if he had been employed in abstract calculations; and his inventive powers do not appear to have been at all of the same class with his retentive faculties; although certainly in the mechanical pursuit of the fashionable methods of modern analysis, which are intended, like steam engines, to overcome all difficulties by the inanimate force of mere patience and perseverance, he was capable of filling as distinguished a place as any living algebraist. The classical prize medal, and the university scholarship, he obtained without difficulty, as matters of course. The exercise, which he exhibited upon the examination for the scholarship, is the well known translation of an epitaph into Greek iambics; which, although not free from some inaccuracies in the use of the tenses, is still a very remarkable production, when it is considered as having been completed in less than an hour, with the help of Morrell's *Thesaurus* only, and never afterwards corrected.

He obtained a fellowship of Trinity College in 1781, and took his degree of Master of Arts in 1785; but not thinking it right to subscribe the Articles of the Church of England, he could not enter into orders, and he was therefore unavoidably deprived of his fellowship in 1791, having no dependence left for his subsistence through life, but his own abilities and acquirements. His friends, however, did not abandon him on this urgent occasion, and in order to keep him out of actual want, a private subscription was set on foot, to which Mr. Cracherode was one of the principal contributors, and by which enough was raised to purchase him an annuity of about L.100 a-year for life. A small addition was made to his income, about two years afterwards, by his election to the Greek Professorship at Cambridge, with a salary of only L.40 a-year. The situation, however, gave him the option of at least doubling his whole receipts, by the delivery of an annual course of lectures in the university; and it was supposed that he would have made this exertion, if he had not been discouraged by the difficulty of obtaining rooms in his college, where it would have been his wish to reside.

Porson married, in 1795, Mrs. Lunan, a sister of the late Mr. Perry, well known as the editor of the *Morning Chronicle*, but he had the misfortune to lose his wife two years afterwards. Mr. Perry continued to be his greatest friend through life, and was so far his best benefactor, as he knew how to oblige him essentially, without the appearance of doing him a favour. Porson had sometimes chambers in the Temple, and sometimes he lodged at the *Morning Chronicle* office; frequently also he was a visitor at Mr. Perry's house at Merton, where he had the misfortune to leave several of his books, at the time of a fire, which destroyed them all, and amongst them some letters of Rhunkenius, with whom he had begun a correspondence in 1783, and who had committed to him some valuable fragments of Æschy-

 lus, besides his manuscript copy of the lexicon of Photius, which had cost him ten months' labour. He used indeed to say that this fire had destroyed the fruits of twenty years of his life; but he had the resolution to complete a second copy of the Photius, which is now in the library of Trinity College. His fondness for the mechanical employment of his pen has been regretted by some of his biographers, as having tempted him to waste much of his most valuable time on a trifling amusement; but in fact, his mode of writing Greek was fully as much calculated for expedition as for beauty; and those who have not been in the habit of correcting mutilated passages of manuscripts, can form no estimate of the immense advantage that is obtained, by the complete sifting of every letter, which the mind involuntarily performs, whilst the hand is occupied in tracing it; so that, if the correction of Photius was really worth the labour of two years of Porson's life, it would have been scarcely possible to employ the greater part of those years more advantageously, than by copying him twice over. Mr. Weston, in speaking of "his matchless penmanship," has observed, not very intelligibly, that "here, indeed, he thought himself surpassed by" another person "not in the stroke, but the sweep, of his letters." What Porson really said on this subject was, that, with respect to "command of hand," that person had the advantage, but he preferred the *model* on which his own hand was formed. His writing was, in fact, more like that of a scholar, whilst the method explained in Mr. Hodgkin's *Calligraphia* exhibits more the appearance of the work of a writing master; holding, however, a middle place between the neatness of Porson, and the wonderful accuracy of the country schoolmaster who made the fac simile of the Oxford Pindar in the British Museum.

Upon the establishment of the London Institution, his friends obtained for him the very desirable appointment of principal librarian, with a salary of L.200 a-year, and apartments in the house of the Institution, which was then in the Old Jewry; but although the arrangement was highly honourable to all parties, the librarianship was little more than a sinecure. Porson was, however, in the habit of attending in his place when the reading-room was open, and of communicating, very readily, all the literary information that was required, by those who consulted him respecting the object of their researches. Had the inhabitants of Finsbury Square and its neighbourhood been more disposed to classical studies, and had the librarian of the Institution survived, to witness its completion and prosperity, his sphere of utility would, without doubt, have been greatly extended.

But it must ever be lamented that Porson's habits of life had unfortunately been such as to lay a foundation for a multitude of diseases. He suffered much from asthma throughout the year 1808; his memory began to fail him a little; and in the autumn he had some symptoms of intermittent fever. On Monday the 19th of September he had an apoplectic attack in the street, and he was carried to a neighbouring poor house in a state of insensibility. The next day an advertisement appeared in one of the papers, relating the accident, and describing some manuscripts which were found in his pocket, consisting of Greek fragments and algebraical characters. His friends at the London Institution immediately went in quest of him; he was afterwards well enough to appear in the library, and to receive a visit there from Dr. Adam Clarke; but his speech was impaired, and his faculties evidently imperfect. He survived only through the week, and died in his forty-ninth year, on Sunday the 25th of September 1808, at midnight.

He was buried at Cambridge, in Trinity College Chapel, near the grave of Bentley, and the monument of Newton. He founded by will an annual prize, to be given to the best Greek translation from an English dramatic author; and several specimens of the successful pieces have been published from time to time in the *Classical Journal*. His books were sold by auction, and many of them found purchasers at high prices, especially such as were enriched with any of his manuscript notes in their margins; but more than two hundred of these, which appeared to be the most valuable, were withheld from the sale, and were afterwards purchased, together with the whole of his manuscript papers, by the Society of Trinity College, for the sum of a thousand guineas. He left a sister, married to Mr. Siday Hawes, of Coltishall, Norfolk. His brother Thomas kept a boarding-school at Fakenham, and died, without issue, in 1792: his second brother, Henry, was a farmer in Essex, and died young, leaving three children. His father had lived to 74, his mother to 57.

The principal works of Porson are his *Letters to Travis*, his four plays of Euripides with their prefaces, and the manuscript copy of Photius; the rest, though somewhat voluminous, are chiefly miscellaneous annotations upon detached passages of a multitude of ancient authors. We find nothing in the nature of theory, or of the discovery of general laws, except some canons, which he has laid down, chiefly as having been used by the Greek tragedians in the construction of their verses. These are chiefly contained in the preface to the *Hecuba*, together with its supplement. 1. The first is, that when a tragic iambic ends with a trisyllable, or a cretic, this word must be preceded either by a short syllable, or by a monosyllable. For example, an ancient tragedian would not have written the line Ἔχοι δὲ μήποτ' ἐξ ἀπευκτοῦ δώματος, though it might have been unexceptionable in a comedy. It seems to have been about the year 1790 that Porson first made this observation. He certainly did not attend to it in his own serious translation of the *Epitaph on Alexis;* but it was mentioned, in 1791, by one of Porson's intimate friends, in a moment of conviviality, whilst he was somewhat characteristically attempting to fill his glass out of an empty bottle; and the author of this article observed in answer, that it would certainly sound better, on such an occasion as then occurred, to say, Πᾶν ἐκπέπωκας· οὐδ' Ἔνεστι κόνταβος, than οὐ λελειπται κόνταβος. 2. The second canon is, that an anapaest is only admissible in a tragic iambic, as constituting the first foot, except in some cases of proper names. This indeed had been cursorily hinted by Dawes. 3. The same critic had also remarked, that the Attic poets never lengthen a short vowel before a mute or aspirate, followed by a liquid, or a middle consonant followed by ρ; and Porson more amply confirmed the observation as very generally, though not universally correct. On the other hand, Dawes had cursorily observed that Homer, and the other ancient epic poets, generally lengthened the vowel in such cases, and Porson's great rival, Hermann, has more fully established this distinction, as affording a good criterion of antiquity. 4. There are also some original remarks of Porson on the caesura, in iambics, and trochaics, and anapaests. He showed that the scenic poets do not elide the final iota, and that the tragedians do not employ the preposition περὶ before a vowel; and some other general laws, of greater importance than these, may probably be found in some of his publications, which it will now be necessary to enumerate in the order of time.

1. His first attempts, as an author, consisted of some anonymous articles in Dr. Maty's *Review*, beginning with a part of Shutz's *Æschylus*, June 1783, *Tracts* ii. Brunck's *Aristophanes*, July 1783, *Tracts* iii.; *Mus. Crit.* ii. 113; written in a day. In Latin, by Schäfer, *Class. Journ.* v. 136. Weston's *Hermesianax*, April 1784, *Tracts*, iv. Huntingford's *Apology for his Menostrophics*, August 1784, *Tracts* v. *Account of the Learned Pig*, April 1785, *Tracts* vi. *Note*, with letters of Le Clerc and Bentley, April 1786, *Tracts* vii.

2. He added some *Notes* to an edition of Xenophon's *Anabasis*, published by Nicholson, at Cambridge, 4to and 8vo, 1786. They are addressed *Lectori si quis erit.*

Badajoz, a page of Athenaeus on cups, or of Eustathius on Homer, even though he did every thing to impair his mental faculties." It cannot, however, be denied, that the talents, and even the industry, that he possessed, might have made him a much greater man, had they been employed in some other department of human intellect. He might *probably* have been as great a statesman or as great a general as he was a scholar, and in these capacities his acquirements would have affected the interests of a much greater multitude of his fellow-creatures, than can ever be benefited by the fruits of his erudition; and he might *possibly* have gained more popularity as an orator or a poet, than his refined investigations of grammar and prosody could ever procure him, although it is not by any means certain that his fancy and invention could have been rendered by any cultivation at all comparable to his memory and acuteness. But as far as regards the possession of a combination of the faculties which he did cultivate, he appears to have been decidedly the most successful of any man on record in the same department. On the other hand, it must be admitted that the subjects of his pursuits were in their nature incapable of raising a man to the first rank amongst the permanent benefactors of the human race; and, if we calmly consider the ultimate objects of prosody and metre, it will appear almost unfair to allow the discoverer of the prosodiacal rules, adopted by the ancient poets in their melodrames and choruses, to rank so very high amongst the luminaries of an age, and yet to look down, with so much contempt as we are accustomed to do, on the character of a modern *Dieu de la danse*, notwithstanding that he thought himself the third great man of his day, with Voltaire and the King of Prussia, for having given soul and sentiment to the measures and movements of the choric representations of the present times.

Amongst the talents of Porson, however, which were so far superior to the importance of the objects on which they were employed, we ought not, perhaps, to consider his remarkable strength of memory as the most to be envied, since many persons who have been possessed of singular and almost miraculous, not to say morbid, memories, have been but little distinguished by any other faculty. It appears to be possible that a memory may in itself be even too retentive for real practical utility, as if of too microscopic a nature; and it seems to be by a wise and benevolent, though by no means an obvious arrangement of a Creative Providence, that a certain degree of oblivion becomes a most useful instrument in the advancement of human knowledge, enabling us readily to look back on the prominent features only of various objects and occurrences, and to class them and reason upon them, by the help of this involuntary kind of abstraction and generalization, with incomparably greater facility than we could do, if we retained the whole detail of what had been once but slightly impressed on our minds. It is thus, for example, in physic, that the experienced practitioner learns at length to despise the relation of individual symptoms, and particular cases, on which alone the empiric insists, and to feel the value of the Hippocratic system of "attending more to the prognostic than the diagnostic features of disease;' which, to a younger student, appears to be perfect imbecility. And it is perhaps for some similar reason that many persons, besides Barnes, "of happy memory," have had to wait long in darkness for "the day of judgment." But it must be repeated, that Porson's judgment and acuteness were really almost paramount to his memory; and with the addition of these faculties, his memory naturally rendered him capable of much that would have been impossible without it.

The respect that is justly due to classical learning has frequently been exaggerated in this country, partly, perhaps, on account of the awe which is naturally entertained, by an ingenuous mind, for its instructors in the earliest studies, by which it is advanced towards maturity. And classical learning having most wisely been placed by our ancestors the foremost, in the order of a liberal education, which is most commonly adopted in Great Britain, a personal as well as a general respect has been involuntarily paid to the characters of the individuals concerned, and to the dignity of all those who are engaged in similar occupations; besides that, the means being, by a most frequent inattention of the human mind, confounded with the end for which they are sought, the words and syllables, and the phrases and measures of the Greek and Latin authors have often been the almost frivolous occupation of a valuable life, instead of that of a few of the years of boyhood, which it was intended to devote to them, and which could not have been so well engaged in any other way. It is, however, wholly unjust to stigmatize the study of the classics, and of languages in general, as being confined to words instead of things; for it is utterly impossible that words can be learned, without the acquisition of a considerable degree of knowledge of the things to which they relate, and of the historical facts which they have been employed to express, and without an involuntary modelling of the mind to the elegance and elevation of sentiment, which pervade the works of those authors who are habitually put into the hands of boys in the course of their elementary studies; an acquirement which is of still greater value to the orator and the statesman, than the command of language, and facility of expression, and beauty of imagery, and power of reasoning, which he derives from a perfect familiarity with the great masters of antiquity. But granting all the respect that can possibly be claimed for ancient literature, we cannot but lament that such a man as Porson should have lived and laboured for nearly half a century, and yet have left little or nothing to the world that was truly and originally his own.

After the full admission of the very high rank which is due to the comparative merits of Porson's talents and acquirements, it may be thought almost idle, if not invidious, to dwell on any trifling exceptions to their magnitude. But it is, in fact, of high importance to the progress of human knowledge, to be aware of the degree in which the first of mankind are liable to error. The admission of the few errors of Newton himself, is at least of as much importance to his followers in science, as the history of the progress of his real discoveries. And it is with reason that the detection of an error in such a man is considered as almost paramount to the establishment of a new fact. The English critics have been reproached, and not without some foundation, as paying too servile a deference to Porson's opinions; and it seems to have been very generally believed amongst them, that it was scarcely possible for him to commit an error or an oversight.

Although Porson was in many respects irregular, and often idle, or even intemperate, yet what he did perform as a critic, may be allowed to leave a large balance, at the end of his life, in favour of his general industry, when compared with that of most of his countrymen. It has indeed been asserted, and perhaps with truth, (*Classical Journal*, xxi.) that "with things Porson appears to have possessed but a very inconsiderate acquaintance; and not a trace is to be found amidst his writings, of that combination of universal encyclopædiacal knowledge with language learning which is so abundantly found in the *Dissertation on Phalaris*, and the countless pages of Scaliger, Salmasius, and Casaubon." Certainly, however, neither Salmasius nor Casaubon, with all their learning, much less Scaliger, with all his industry and parade, nor even Bentley himself, with all his talent and acuteness, was at all comparable to Porson in his own department, that is, as a sound, and accurate, and refined Greek critic.

But it must be confessed, that at Cambridge, even although Porson had resolved to make the classics his principal study, and although there had not yet been many in-

Porson.

stances of senior wranglers, who were also senior medallists, it was scarcely reputable for a man, with his undeniable abilities, to be only the twenty-first of his year in mathematics. Amongst the literary objects also, which afterwards engaged his attention, he might easily have found time for the study of some of the modern languages; and he might have derived essential benefit from it on many occasions of critical research. He had, indeed, read a good deal of French, but very little Italian. He had studied the Anglo-Saxon, but he knew nothing of the kindred dialects of the north of Europe, in which it is preserved almost entire; and he was wholly unacquainted with Oriental literature. He might have profited materially by some of these studies, in deriving from them a clearer conception of the distinctions of the tenses than he seems to have possessed, and he might have enlightened us in no small degree, with respect to the history of languages and of nations, by such etymological investigations as his comprehensive mind, thus employed, would have rendered him peculiarly capable of pursuing with success.

It has been candidly and very truly admitted by a rival critic in Germany, that Porson committed fewer errors than almost any other person; but it is right to be aware that he has now and then committed some errors, even where he would have been expected to be the most correct. There is, for example, a very strange oversight in one of the criticisms contained in his early review of Weston's *Hermesiananax*, which implies a palpable blunder with respect to the gender of a participle, Ζωρὸν μετροῦσα θυῶν πορφυρέης Λυσβιον ἐὲ ὑέλου, "the cup of purple glass, which *measured* the fragrant wine;" and even in a subsequent correction of the same passage, published in his *Adversaria*, he has changed the gender of an adjective in a way that is at least very unusual, if not wholly without example, μετροῦν θυόεντα. A mere omission, in a criticism on another author, would scarcely be called an error in an ordinary person; but in such a critic as Porson, it is very remarkable that he should have neglected to notice, in his catalogue of the *Errors of Le Clerc*, omitted by Bentley, (*Adv.* p. 291,) the grossest of all Le Clerc's blunders, which is the quotation of the word *Hypophauli* or *semibarbarous*, from Pollux, with the translation *Sartagines*, or *frying pans;* whilst the real text of Pollux simply and plainly states that the *Teganismi* or *fricassations*, in the *Hippocomus Menander*, is *a semibarbarous word*. These instances, which have occurred in a very cursory perusal of some of Porson's works, would certainly not deserve to be noticed in a general sketch of his character, any otherwise than as exceptions to his perfect infallibility.

It can scarcely be considered as an imperfection in the constitution of Porson's mind, that he wanted that amiable vanity, which is gratified by the approbation even of the most inconsiderable, and which delights to choose for its objects the most innocent and the most helpless of those who are casually present in society. It has been observed that he would neither give nor take praise; and when he was told that somebody had called him a giant in literature, he remarked that a man had no right to tell the height of that which he could not measure. In fact, having learned "to know how little can be known," it is not surprising that he found himself "without a second, and without a judge;" and that he was unwilling to affect a community of sentiment, and an interchange of approbation with those whose acquirements and opinions he felt that he had a right to despise. It might have been wiser, in some instances, to conceal this feeling; but, on the other hand, he had perhaps occasion for something of the habit of retreating into his conscious dignity, from his deficiency in those general powers of ephemeral conversation, which are so valuable in mixed societies; for, with all his learning and all his memory, he was by no means prominent as a talker. He had neither the inclination nor the qualifications to be a fascinating story teller, or to become habitually a parasite at the tables of the affluent; but he was the delight of a limited circle of chosen friends, possessing talent enough to appreciate his merits, and to profit by the information that he afforded them.

Port ‖ Portaferry.

There has not yet been a life of Porson that has collected all the particulars that would deserve to be recorded by a biographer, who undertook the task on an extensive scale; but of detached documents there is no deficiency. Mr. Kidd has pointed out almost every work in which his name has been mentioned. The most material articles relating to him will be enumerated here.

Morning Chronicle, 6th October 1808. *A Short Account of the late Mr. Richard Porson, with some particulars relative to his extraordinary talents;* by an admirer of great genius (the Rev. S. Weston,) Μηκέτι πάπταινε κόρσιον, Look for nothing beyond him. London, 1808, 8vo. Republished, with some additions, under the title of *Porsoniana, or Scraps from Porson's Rich Feast*, London, 1814, 8vo. Bloomfield's *Sapphic Ode, Class. Journ.* i. 1. *Some anonymous Iambics*, p. 81. *Sale of his Library*, p. 385. *Athenæum*, iv. 426, 521; v. 55. *Class. Journ.* ix. 386. Savage's *Librarian*, i. 274. *Gentleman's Magazine*, lxxviii. *Monthly Magazine. Dr. Adam Clarke's Narrative. Class. Journ.* ii. 720. *Correspondence of Wakefield and Fox*, London, 1813, 8vo. *Greek Epitaph, Class. Journ.* xxiii. 179; making Porsōnum equal to Newtŏnus. Aikin's *General Biography*, x. London, 1815, 4to. Kidd's *Imperfect Outline. Tracts*, 1815. Chalmers's *Biographical Dictionary*, xxv. London, 1816. L. L.

PORT, a harbour, river, or haven, formed either by nature or art to receive and shelter shipping from the storms and waves of the open sea.

Artificial ports are those which are either formed by throwing a strong mound or rampart across the harbour's mouth to some island or rock, or erecting two long barriers, which stretch from the land on each side like arms or the horns of a crescent, and nearly enclose the haven. The former of these are called *mole-heads*, and the latter *piers*.

Port, is also a name given on some occasions to the larboard or left side of the ship, as in the following instances. Thus, it is said, "the ship heels to port," that is, stoops or inclines to the larboard-side. "Top the yard to port," the order to make the larboard extremity of a yard higher than the other. "Port the helm," the order to put the helm over the larboard-side of the vessel. In all these senses this phrase appears intended to prevent any mistakes happening from the similarity of sounds in the words *starboard* and *larboard*, particularly when they relate to the helm, where a misapprehension might be attended with very dangerous consequences.

Ports, the embrasures or openings in the side of a ship of war, wherein the artillery is ranged in battery upon the decks above and below.

PORTADOWN, a thriving post-town, in the county of Armagh, Ireland, 66 miles from Dublin. It is situated on the Upper Bann, navigable here for vessels of 60 tons burden, and is by it connected with the Newry Canal. It has of late years been much improved, and its appearance is now highly respectable. The principal trade is in the agricultural produce of the surrounding country, which is forwarded to Newry by the canal, whilst the returning barges bring slates, coal, iron, &c. for the inland market. A good number of hands are employed in the linen and cotton trade. The population in 1831, amounted to 1,591.

PORTAFERRY, a sea-port town, on the eastern shore of the entrance into Strangford Lough, county of Down, Ireland, 80 miles from Dublin. It consists of a small square, a few streets, a range of houses on the quay, and several places for public worship. The principal trade is carried on

Portal ‖ Port-au-Prince.

with the Liverpool and Glasgow markets, for the agricultural produce of the neighbourhood. The population in 1821 was 1512, and in 1831, 2203.

PORTAL, in *Architecture*, a little gate where there are two gates of a different size; also a little square corner of a room cut off from the rest by the wainscot, and forming a short passage into the room. The same name is also sometimes given to a kind of arch of joiners' work before a door.

PORTALEGRE, a city of Portugal, in the province of Alentejo, the capital of a corregimiento of the same name. It is situated on a hill about seven miles from the frontiers, and strongly fortified, being defended by a citadel and many extensive outworks. It is the see of a Bishop, who has a fine cathedral, and under his care an ecclesiastical seminary. There are in this town four parish churches, and five religious houses, with some charitable institutions. It contains 1127 dwelling-houses, with 5780 inhabitants, who make a large quantity of woollen cloth, especially such as is adapted for the troops; and there are carried on some other branches of manufacture.

PORT ANNA MARIA, a bay or harbour on the south coast of Sir H. Mertin's island, in the South Pacific Ocean, seven miles west of Point Mertin. Long. of the entrance 139, 39. W. Lat. 8. 30. S.

PORTARLINGTON, a borough town, situated in King's County and Queen's County, Leinster, Ireland. It is 44 miles from Dublin, and is situated on the river Barrow, which divides it into two parts, and it consists principally of one long street, about two miles in length. The houses are generally large, and regularly built; but the town possesses neither commerce nor manufactures, nor is it situated on any high road of communication. The prosperity of the town depends on a greater proportion of gentry residing in it, than is generally to be found in towns of its size in Ireland; and also on the reputation of its schools. There are two Protestant churches, a Methodist, and Roman Catholic chapel. The borough possessed, before the year 1784, a large property; but the corporation in that year, and in the year 1802, conveyed over to Lord Portarlington, the patron of the borough, the whole of the property, which brings yearly to the noble proprietor L.800 sterling, and for which he pays to the corporation the sum of L.60 late Irish currency. The borough is governed by a sovereign, two bailiffs, and a recorder, and it returns one member to parliament. The population in 1821, amounted to 2877, and in 1831, to 3091.

PORTATE, or a Cross Portate, in *Heraldry*, a cross which does not stand upright, as crosses generally do, but lies across the escutcheon in bend, as if it were carried on a man's shoulder.

PORT-AU-PRINCE, the capital and seat of government of the republic of Hayti, formerly called St. Domingo or Española, one of the West India Islands. It stands at the bottom of the large bay of the same name, in a situation so low and marshy as to render the climate very unhealthy. It is mostly built of wood; the streets are broad but unpaved; nor are any of its edifices remarkable for their architectural elegance. It contains the president's palace, several literary and scientific institutions, a lazaretto, and some other public buildings. There is an academy for medicine, astronomy, law, literature, and other branches of knowledge; a drawing seminary, Lancasterian and primary schools, and a national library. There is also a military school, where the pupils receive instruction gratuitously; and several newspapers and periodical journals are published here. The city is supplied with water by a conduit three English miles in length. It has a spacious and secure port and roadstead, where five hundred vessels may anchor at once. It is surrounded by hills which command the town and harbour; and both the hills and the vallies are abundantly fertile. To the east is situated the noble and celebrated plain of Cul de Sac, extending from thirty to forty miles in length, by nine in breadth. It is chiefly laid out in sugar plantations, most of which can be watered in times of drought by means of canals admirably adapted for the purpose. Commerce is the principal occupation of the inhabitants of Port-au-Prince. The amount of imports may be estimated at twenty millions of francs; but the exports, consisting chiefly of coffee, cotton, Campeachy wood, sugar, and other articles, are much greater. This city was founded in the year 1745; but twenty-five years afterwards it was almost completely destroyed by an earthquake. It was rapidly rebuilt, but was nearly reduced to ruins by fire in 1791. In 1830, it again experienced several shocks of an earthquake, some of which did considerable damage. The inhabitants of the district of Port-au-Prince are estimated at about 90,000, and those of the city at about 30,000. Lat. 18. 34. N. Long. 72. 27. W.

Portcullis ‖ Port-Glasgow.

PORTCULLIS, in *Fortification*, is an assemblage of several large pieces of wood, joined across one another like a harrow, and each pointed with iron at the bottom. They are sometimes hung over the gate-way of old fortified towns, ready to be let down in the case of surprise, when the gates cannot be shut.

PORT-DALRYMPLE, a harbour or estuary on the north coast of Van Dieman's Land, in which the Tamar discharges itself, after receiving the North and the South Esk. At the union of the latter it is navigable for vessels of 150 tons.

PORTER, a kind of malt-liquor which differs from ale and pale beer, in its being made with high-dried malt. See Brewing.

PORT-GLASGOW, a sea-port town of Scotland, is situated on the south bank of the Frith of Clyde, in the shire of Renfrew, about nineteen miles below Glasgow, and three above Greenock. This place originally formed part of the adjoining parish of Kilmalcolm, and consisted of the small village of Newark, so called from the barony of that name, which lay in its immediate vicinity. On a point of land projecting into the river, a little above the town, is situated the ancient and now deserted castle of this barony. The ground on which the town stands was, in 1668, purchased from Sir Patrick Maxwell of Newark, by the magistrates of Glasgow, with a view to provide a convenient harbour for the vessels belonging to the merchants of that city. A harbour was therefore constructed, and streets were laid off, according to a regular plan. In 1695 the place was, by the competent authority, detached from the parish of Kilmalcolm, and, with a few adjacent farms, erected into a distinct parish, approaching in form nearly to a square, and not exceeding an English mile either in length or in breadth. It was called New Port-Glasgow, or more commonly Port-Glasgow, a name simply expressing the design of its erection as the port or harbour of Glasgow. In 1775 it was created a borough of barony; and by the reform act of 1832 it became a parliamentary borough of the third class, uniting with Kilmarnock, Rutherglen, Dumbarton, and Renfrew, in returning a member.

Port-Glasgow is one of the most handsome and regularly built sea-port towns of Scotland. The streets are straight, and for the most part cross each other at right angles; whilst the houses, pretty nearly equal in size, and generally whitewashed, give to the whole a light and uniform appearance. The only buildings worthy of particular notice are the town-house and the parish church. Of these the former is of plain but substantial workmanship, ornamented in front with a portico, resting on four massy fluted columns, surmounted with a handsome spire, which rises from the centre. The parish church was built in 1823. It is square in form, and plain in outward appearance, but is deservedly admired for the simple elegance of its internal construction. A commodious chapel of ease belonging to the establishment was built in 1774. The only other place of worship in the parish belongs to the Associate Synod.

Port-Glasgow.

The land of this parish church lies along the bank of the river, having been long occupied as gardens, presenting a rich and highly cultivated appearance. The town itself is romantically situated at the bottom of a hill, which, covered with wood and verdure, exhibits a beautiful object to travellers passing along the river.

Attached to this port are two capacious harbours, substantially built, and completely sheltered from the storm. The first dry or graving-dock in Scotland was constructed here in 1762, and has since been improved at great expense. Some years ago, the harbour accommodation having been found too small, the inhabitants resolved to avail themselves of their local advantages, by converting the bay of Newark, which is naturally adapted to the purpose, into a spacious dock, where vessels of the largest class might be kept securely afloat in every state of the tide. Accordingly, in June 1830, the trustees of the harbour obtained an act of parliament, investing them with the necessary powers; and the work, which was contracted for by Mr. Gibb, an eminent architect, was commenced in the spring of 1834, and carried on with every dispatch until 1836, when a small portion of the outer wall gave way. In consequence of this untoward incident, the operations were considerably impeded, and it was even deemed expedient to erect a ruble breakwater, to enable the trustees to restore the outer wall so soon as the works had been allowed sufficient time to consolidate. As a substitute for the outer wall, and in order to secure the full benefit of the wet-dock, the trustees have, in the mean time, resolved to construct a wooden wharf on the outside. The works having since been considered as sufficiently consolidated, and the inner walls having afforded abundant evidence of their stability, the necessary sheds, together with the wharfs alluded to, have lately been contracted for, and are at present in rapid progress; so that this important undertaking, which has cost its enterprising promoters about L.40,000, may now be considered as completed. Many ships have already discharged their cargoes in it. Besides the numerous sail of merchantmen at present, (December 1838), within its walls, there is the British Queen, steam-ship, (receiving her machinery), the largest vessel ever built in the United Kingdom. This is the only wet-dock of the kind on the west coast of Scotland. It extends over a space of twelve imperial acres, is 25 feet deep, has an entrance-gate of 55 feet in width, is provided with spacious quays and commodious sheds, cranes, and other conveniences, and possesses extraordinary facilities for ingress and egress, owing to the great depth of water in the roads and entrance, and the protection afforded by the lofty hills by which the dock is sheltered. With all these advantages, in addition to an extensive tide harbour, Port-Glasgow now affords shipping accommodation of a very superior description. The charges on shipping at this port are much lower than at any other in Scotland. This is in a great measure owing to the extensive bonded warehouses held by the corporation, situated alongside the dock-walls, where every description of goods may be deposited at trifling rates.

The foreign trade of this port is chiefly with the West Indies and North America. It is the principal place on the Clyde for the importation of North American timber, for the reception of which it has large wood-ponds. Not less than 27,975 tons were imported in 1834. A comparative view of the tonnage employed in the foreign trade of the town during the last eight years indicates considerable improvement; the average inward tonnage for the four years prior to the 5th of January 1834 having been 23,901, and for the four years ending the 5th of January 1838, 28,761 tons. The harbour revenue exhibits a corresponding annual increase. In 1831, the harbour-dues amounted to L.1454; in 1834, to 1639; in 1836, to L.1800; and at present they average about L.2000 per annum. The customs collected have for the year ending in January 1838 amounted to L.94,161, a sum much less than what was received a few years ago. But the deficiency is not to be attributed to any decline of trade; for under the existing laws the amount of customs collected at any warehousing port forms no criterion for ascertaining the real extent of its commerce. The deficiency is attributable to two causes, which bear no direct reference to the decline or the improvement of trade; namely, first, the collection at Glasgow since the year 1834, of the duties upon tobacco, which were formerly paid here; and secondly, the facilities afforded by recent laws for recovering bonded goods from the port of importation without payment of the duty. Thus, merchandize of every description, although imported here, is daily removed under bond to other places, where the duties are paid, which causes a diminution of the customs paid at this port, and may at first sight lead to the inference that the commerce of the place is declining, whilst, in point of fact, it is on the increase.

Portgreve ‖ Port-Jackson.

The coasting trade of Port-Glasgow was at one time very considerable; but owing to the great facility with which vessels of inferior burden now find their way up the river, nearly the whole of this branch has been transferred to Glasgow.

The work of ship-building is carried on here to a considerable extent. Of late years the carpenters have been chiefly employed in the construction of steam-boats, of which they have produced a great number, some of them of the largest class, and all of them of remarkable symmetry and superior workmanship. The manufacture of ropes and sail-cloth has been prosecuted for about a century. A considerable trade is carried on in sugar-refining.

In 1700 the population was not more than 400 souls; but in 1718, the inhabitants amounted to twice that number. From this period the population continued steadily, though not rapidly, to increase until the year 1790, when it consisted of 4036 persons. At each of the four decennial censuses which have since been taken, it was as follows:—In 1801, 3865; in 1811, 5116; in 1821, 5262; and in 1831, 5192. From a survey which was taken expressly for the New Statistical Account, in the summer of 1835, it was ascertained that the population had increased to 6018. The comparatively slow increase of population in this place, and its occasional falling off, as above indicated, are referable to the fluctuations of foreign trade, and to the depressing influence of the neighbouring ports of Greenock and Glasgow.

PORTGREVE, or PORTGRAVE, was anciently the principal magistrate in ports and other maritime towns. The word is formed from the Saxon *port*, a port or other town, and *geref*, a governor. It is sometimes also written *portreve*. Camden observes, that the chief magistrate of London was anciently called *portgreve;* but instead of him, Richard I. appointed two bailiffs; and soon afterwards John granted them a mayor as their yearly magistrate.

PORTICI, a palace of the king of Naples, six miles from the capital, and charmingly situated on the sea-shore, near Mount Vesuvius. It is enriched with a vast number of fine statues, and other remains of antiquity, taken out of the ruins of Herculanum. See POMPEII.

PORTICO, in *Architecture*, a kind of gallery formed on the ground; or a piazza encompassed with arches supported by columns, where people walk under covert. The roof is usually vaulted, but sometimes flat. The ancients called it *lacunar*. Though the word *portico*, be derived from *porta*, a gate or door, yet it is applied to any disposition of columns which form a gallery, without any immediate relation to doors or gates.

PORT-JACKSON, a bay and English settlement on the east coast of New Holland. The two heads through which the entrance lies are distant from each other one mile and three quarters; and the heads on each side are high, steep,

Portland ‖ Port Sandwick.

perpendicular cliffs, between which ships may run in safety. It may be entered in all winds. Within, the port divides into two branches, the one stretching eighteen miles west, the other seven miles north-west. Both contain numerous creeks, on one of which is situated the town of Sidney, the chief town of Botany Bay. Long. of Castle Point, 151. 11. 49. E. Lat. 33. 51. 45. S.

PORTLAND, a town of Maine, one of the United States of North America. See MAINE.

PORTLAND, an island on the coast of Dorsetshire, or rather a peninsula, since it is joined to the mainland by a lofty bank of pebbles, which runs parallel to the sea, about three miles in length. Within the beach is a small arm of the sea, called the Fleet, the passage over which, by a ferry, is the common communication with Weymouth, from which it is distant about three miles. The island is a solid mass of stone, peculiarly adapted for buildings of the first class; and the extracting it from the quarries, and placing it on vessels, form the chief employment of the inhabitants. The surface of the rock is covered with a soil, the herbage of which feeds a small race of sheep, celebrated for the delicate flavour of their flesh. Some cows are also kept, and a small part of the land yields corn, but not sufficient for the inhabitants. The parish comprehends seven hamlets. It has a church near the centre; and towards the south end is the well constructed light-house, so important to navigation. Portland road is a secure anchorage, and is defended by a small fort. Lat. of the light-house 50, 31. 22. Long. 2. 26. 59. W. The population was in 1801, 1619; in 1811, 2079; in 1821, 2254; and in 1831, 2670.

PORTLAND ISLANDS, is a cluster of small islands in the Eastern Seas, to the westward of New Hanover. They were so named by Captain Cintenet in 1767. The north-east point of the most eastern isle, is in Long. 147. 18. E. Lat. 2. 36. S.

PORTLAND ISLAND, in the South Pacific Ocean, is situated near the east coast of New Zealand. Long. 178. 12. E. Lat. 39. 25. S.

PORTLAND VASE, a celebrated funeral vase, long in possession of the Barberini family, but which was purchased for a thousand guineas by the Duke of Portland, from whom it derived its present name. Its height is about ten inches, and its diameter where broadest six. There are upon it a variety of figures of most exquisite workmanship, in bas relief, of white opaque glass raised on a ground of deep blue glass, which appears black except when held against the light. It seems to have been the work of many years, and there are antiquarians who date its production several centuries before the Christian era; since sculpture was declining in excellence even in the time of Alexander the Great.

PORT LOUIS, a fortified sea-port of France, in the department of Morbihan, and arrondisement of L'Orient. It is situated at the mouth of the river Blavet, on the bay of its own name, and is inclosed by the sea on three sides. It has a citadel of great strength, three churches, a naval hospital and exchange, 365 houses, and 3480 inhabitants. Lat. 47. 45. Long. 3. 32. W.

PORT-MACQUARIE, an inlet on the east coast of New Holland, into which falls the river Hastings. It received its present appellation from Mr. Oxley, who surveyed it in 1818. Long. 152. 53. 54. E. Lat. 31. 25. 115. S.

PORT-ROYAL, a town of the island of Jamaica. See JAMAICA.

PORT-SANDWICK, a harbour of the island of Mallicollo, in the South Pacific Ocean. Long. 167. 67. E. Lat. 16. 25. S.

Portobello ‖ Porto Rico.

PORTOBELLO, a parliamentary burgh, situated on the Frith of Forth, nearly three miles from Edinburgh. The town is neatly built, and as the beach is extensive, and commodious for sea-bathing, it is consequently much frequented in the summer season as a watering-place. It is not a place of trade, but has several manufactories for making bricks, tiles, and potteries, a crystal and glass work, and one or two others of less importance. The town is governed by a provost, two baillies, and six councillors; and, with Leith and Musselburgh, it returns a member to parliament. The stationary population in 1821, amounted to 1912, and in 1831, to 3170.

PORTOBELLO, a town situated on the isthmus of Panama. See PANAMA.

PORTO FERRAJO, the capital of the Island of Elba, in the province of Pisa, and the duchy of Tuscany, celebrated as the residence of Napoleon during his banishment to that island. It is situated on a tongue of land running into the sea, and forming a small bay. It is fortified, and contains two churches, an hospital, 600 houses, with 3120 inhabitants, who depend chiefly upon some salt works and the tunny fishery. Lat. 42. 49. 6. Long. 9. 20. 15. E.

PORTO-NOVO, a sea-port town of the south of India, in the Carnatic. It is esteemed the safest port on the Coromandel coast. The ground is good, and vessels may anchor in six fathoms water. In August 1781, the British gained a victory here over Hyder Aly. Long. 79. 52. E. Lat. 11. 30. N.

PORTO RICO, or PUERTO RICO, one of that group of West India islands called the great Antilles, and the smallest of the four in population and extent, but yielding to none in fertility and general importance. It is situated to the east or windward of Hayti, Cuba, and Jamaica, being separated on the west from the first named island by a channel twenty-five leagues in breadth, and having the Atlantic Ocean on the north, with the Carribean Sea on the south. It is about ninety miles in length from east to west, by thirty-three miles in average breadth; and contains, according to an exact admeasurement, a plane superficies of 2970 square miles.[1] A chain of lofty mountains intersects it from east to west; the highest part, called Luguilla, at the north-east extremity of the island, being 1334 Castillian yards in height. Valleys, levels of table land, and gentle declivities, all highly fruitful, are every where found embosomed in these mountains; and they are themselves susceptible of cultivation to the very tops. To the north and south of this interior ridge, situated between it and the sea coast, are those richly fertile valleys which produce the chief wealth of the island. They are formed by smaller ridges of hills, which run north and south from the principal chain, and are much more level than those situated amongst the loftier mountains, which present an unequal, undulating surface, and a continued succession of gentle acclivities, covered with trees displaying all the varied colours and vivid foliage of the tropics. The valleys of the north and east coasts are the richest in cattle, and the most picturesque, the pasturage there being always verdant and luxuriant, from the abundant supply of rain which they receive; whilst those of the south coast, richer than the north in sugar, are often parched by excessive drought. This, however, can easily be remedied, for water is found by digging only half a yard below the surface of the ground. Few countries of the same extent as Porto Rico are watered by so many streams. Seventeen rivers, taking their rise in the mountains, cross the valleys of the north coast and fall into the sea. Some of them are broad and deep, and navigable for two or three leagues

[1] These are the dimensions assigned to the island by Colonel Flinter in his *Account of the Present State of the Island of Puerto Rico*, 1834. Malte Brun, on what authority does not appear, makes it one hundred and twenty miles in length by forty in breadth; and other geographical writers extend its longitudinal dimensions still further. Probably the discrepancy arises from extreme points being taken in the one case, whilst a medium measurement is that given by Colonel Flinter, who had the most ample means of knowing every thing connected with the island. To his work on Porto Rico we have been chiefly indebted for the present account of it.

Porto Rico.

from their emboucheurs, which, however, are much obstructed by bars. These rivers are well stocked with excellent fish; and the banks of the whole of them are nearly all under cultivation. The south, west, and east coasts are well supplied with water, notwithstanding the unfrequency of rain. There are several large streams, besides numberless rivulets, and branches of navigable water. Porto Rico therefore possesses great natural facilities for inland navigation, particularly upon the north coast. Of course we find the year divided in this island, as in the others belonging to the West Indies, into the wet and dry seasons, the former the winter, the latter the summer. But this distinction does not give a proper idea of the seasons in Porto Rico; for on the north coast it sometimes rains during the whole year, whilst on the south coast a perfect deprivation of rain for twelve or fourteen months is no uncommon phenomenon, even when in the mountains there are daily showers. The climate of the north and south coasts of this island, therefore, are essentially different, although under the same tropical influence. The only difference of temperature to be observed throughout the whole island, is between the valleys and the mountains, which happens in every country similarly situated. In the mountains the inhabitants enjoy the coolness of spring, whilst the valleys, were it not for the daily breeze which blows generally from the north-east and east, would be uninhabitable. In August the atmosphere is oppressively hot, the thermometer being frequently above 90° of Fahrenheit; and during the coldest season it is never below 70°. In September the rains descend like a deluge, and the rivers swell and overflow their banks, completely inundating the low lands, whilst the smallest brooks become deep and rapid torrents. In October the weather becomes cooler, and in the following month the north and north-east winds generally set in, diffusing an agreeable coolness through the atmosphere. When the fury of the north wind abates, the most delightful weather is experienced. Hurricanes, the scourge of the West Indies, sometimes visit this island, generally between the months of July and October. In the year 1825, one occurred on the 27th of July, which nearly laid it desolate. Notwithstanding the general heat of the climate, and the humidity of some parts of Porto Rico, it is reckoned healthy. The number of mountains and running streams, the absence of stagnant water, and the general cultivation of the land, no doubt powerfully contribute to purify the atmosphere and render it salubrious to man. This island exhibits a singular scarcity of indigenous animals. There are no venomous snakes or reptiles, no beast of prey, or indigenous quadrupeds of any kind to be found in the forests, scarcely any of the feathered tribes, and no noxious insects. But rats of an enormous size and in great numbers infest the country, and sometimes commit dreadful ravages upon the sugar canes.

The principal wealth of Porto Rico consists in agriculture. No manufactories are carried on, and no mines of gold and silver have been explored, if such exist. The soil is of the richest description, and a prolific and luxuriant vegetation covers every part of the island. The agriculturist is not limited by the nature of the soil to the exclusive cultivation of any particular produce. Every species of fruit and vegetables, congenial to tropical climates, may be planted with the certainty of reaping an abundant harvest. The best and most luxuriant pasture for rearing cattle; the rich, deep, vegetable mould necessary for the sugar cane; the humid soil in which the cocoa vegetates; and the cool mountain glades, so congenial to the coffee plant, may all be found within a small circle. Cotton, tobacco, and indigo, the latter being a spontaneous product of the fields, only require a little attention to render them objects of importance.

The whole agricultural riches of the island, houses, lands, and slaves, not included, were valued in 1832 at 37,993,599 dollars, and the produce at 6,883,371 dollars; of which there were exported through the custom houses to the value of 3,411,845½ dollars. The contributions levied on this property amounted only to 266,526 dollars, which is less than 3¼ per cent. on the value of property, and less than 5⅞ per cent. on the value of produce. We have no doubt that the value of property and produce is much greater than what has just been stated; for as the people of the country themselves make the valuation, they always endeavour to make it appear as small as possible, in consequence of the direct tax levied on property.

Porto Rico.

Colonel Flinter thinks that there cannot be fewer than two hundred thousand horned cattle on the island, the other animals being proportionally more numerous than they appear to be from the statement given; and he thinks that the total value of the cattle may be estimated at 7,858,774 dollars. A great traffic has long been carried on in them, with the English, French, and other settlements. They bring a higher price than those of South America, in consequence of being fattened from the finest pasture land in the world, and from their extreme tameness. Vast quantities of raw and tanned hides are likewise exported. The production of sugar is the next great branch of industry. That the soil and climate are admirably adapted for the cultivation of the cane will be seen from the following fact. The proportion of sugar produced from the land employed in its cultivation, is in Jamaica and Dominica, ten quintals per acre; in Grenada, fifteen quintals per acre; in St. Christopher's and Tobago, twenty quintals per acre, and in St. Vincent's, twenty-five quintals per acre; whilst in Porto Rico it is estimated at thirty quintals per acre.

Notwithstanding the great natural resources of this island, there are imported, besides manufactured goods, considerable quantities of provisions and other articles, of which, by attention, Porto Rico might be made itself to yield sufficient supplies. However, an examination of the exports and imports shows, that of late years, the produce of the land exported, considerably exceeds the value of goods and provisions imported.

Amount of Exports and Imports for several years.

Years.	Imports. Dollars.	Exports.	Difference in favour of Exports.	Amount of Duties.
1810	1,005,694	662,570	...	...
1828	2,039,928	2,590,726	550,798	522,034
1830	2,208,941	3,411,845	1,202,903	...

In 1830, there entered about 60,000 tons of shipping, of which one-half belonged to America, one-fourth to Spain, and the remaining fourth chiefly to England, France, and Denmark. The importations from America, which in value amount to one-third of the whole, consist of salt fish, flour, butter, lard, grain, lumber, boards, staves, and articles of furniture. The mother country exports her olives and brandies, her wines and dried fruits, oils of olive and almond, carpets for kneeling on, and other manufactures, alpute, anchovies, and so forth. England imports cotton goods, Irish linen, hardware, earthen-ware, and the like; and France imports linens, cambrics, ladies' dresses and ornaments, toys and jewellery. Foreign goods pay seventeen per cent. of importation duties, *ad valorem;* and an export duty of six per cent. is levied on all goods sent from the island, with the exception of timber and live stock, which are charged much higher. Spanish vessels from the peninsula pay six per cent. of importation duty, and the export tax is also much less than it is for foreign vessels. It is scarcely necessary to say, that the exports from Porto Rico consist of live stock, sugar, coffee, tobacco, and the other rich productions of the island. Co-

Porto Seguro.

says Prince Maximilian, "in the provinces of Minas Geraes, Goyaz, and Pernambuco, is divided from the eastern coast, by a broad tract of high forests, which extend from Rio de Janeiro to the Bay of All-Saints (Bahia) about eleven degrees of latitude, and which are not yet taken possession of by the Portuguese settlers; only a few roads have hitherto been opened, with infinite labour, along the rivers that traverse them. In these forests, where the primitive inhabitants, who are pressed upon at every other point, have till now enjoyed a serene and peaceful abode, we may still find those people in their original state." In fact the aborigines of Espiritu-Santo and Porto Seguro have been found more difficult to civilize than any other native tribes in this quarter of the world, and the country itself is still in a great measure uncultivated. The civilized people are wholly confined to the coast, and even there they are not perfectly secure from hostile attacks. Yet the salubrity of the climate, and the fertility of the soil, have rendered this district an object of interest with government, so that settlers have been induced to occupy it. The virgin forests with which it is nearly covered, abound with the finest timber, including the cedar, the sassafras tree, and various other resinous and aromatic species; and no province possesses such an abundance of the tree which supplies the Peruvian balsam. "In the provinces of Espiritu-Santo and Porto-Seguro," says a recent traveller, "are found several kinds of wood suited to cabinet-work and architecture. The Ibirapitanga (Brazil wood) now so necessary in manufactures, and which is beginning to fail in Pernambuco, is met with here," and, we may add, on the authority of others, in abundance.

Between the southern limits of the country and the Rio Doce, which separates Espiritu-Santo from Porto Seguro, are situated several towns and villages, and a few military posts, to secure the settlers from the inroads of the savages. About twenty miles north of the Itabupuana, on the southern bank of the river Itapemirim is a village of the same name, more recently built than the others, and containing some good houses. The inhabitants, who are but few in number, carry on a small trade in sugar, cotton, rice, millet, and timber. The Sera de Itapemirim, from which the river descends, is celebrated for the works for washing gold, called Minas de Castello, five days journey up the Itapemirim. From this place to the frontier of Minas Geraes, a road has been opened through the dangerous wilderness of woods; but it is hazardous to travel along it on account of the savage hordes of Puries and Botucudoes, by which the country is infested. From the village of Itapemirim to the village of Nova de Benevente, the country presents alternate woods and meadows, with a stream at intervals, but no river of any size. Benevente stands at the foot of a hill on the northern bank of the Iritiba or Reritigba, called also the Benevente. This place was built by the Jesuits, who here collected a great number of Indians for the purpose of civilizing them; but the hard labour exacted by the crown drove most of them to other quarters. This was the largest establishment on the coast, and the church and convent erected by the missionaries are still seen in the neighbourhood of the town. Between Benevente and the Rio de Espiritu Santo, which gives name to the province, the country is one continuous and magnificent forest, abounding with multitudes of the feathered tribes. The river Espiritu Santo, which is of considerable magnitude at its mouth, rises in the mountains on the frontiers of Minas Geraes, and descending with many windings, through the extensive ancient forests of the Tapuyas, issues forth at the foot of one of those higher chains of mountains which stretch towards the sea. According to Cazel, the proper name of this river is the Santa Marta. It is stated to be navigable to the first fall, about forty miles up, and the tide ascends twelve miles to the Serra, a river which joins it on the left. Villa Velha, a small and unimportant town, stands on the south bank of the river, not far from its mouth; and about half a league from it, on the opposite side of the bay, is the present capital of Espiritu-Santo, called Villa da Victoria. It is built, according to Cazal, on an amphitheatrical site, on the western side of an island fifteen miles in circumference. It is a pretty neat place, with considerable buildings, constructed in the old Portuguese style. The population of this city is estimated at 12,500. Porto Seguro.

From this town to the Rio Doce, the limits of Espiritu-Santo on the north, there are several rivers and small towns; but generally speaking, not only the interior but the sea-coast is densely wooded. This province comprehends three-fourths of the captaincy, which, in the year 1534, was assigned to Vasco Fernando Coutinho, as a remuneration for his services in Asia. The Portuguese were repeatedly driven from the colony by the natives, but ultimately they obtained a decisive victory over the savages, and effected a permanent settlement. The Jesuits were the first who succeeded in making peace with the aborigines, and in 1551 they founded the college of Vittoria; but, as we have observed, they made little progress in this quarter.

The adjoining comarca of Porto Seguro extends from the Rio Doce to the river Belmonte. It lies between 19° 33′ and 15° 25′ of south latitude, which gives it a length of sixty-five leagues. It was upon this part of the coast that Cabral first set foot, and took possession of Brazil for the crown of Portugal. Some Portuguese having settled here, they intermarried with the natives, so that Pedro Campo Tourinho, its first donatory, found himself, in a few years, the lord of a tolerably well-peopled colony. Santa Cruza town, built on the bay where Cabral cast anchor, soon became considerable and flourished; but the settlement was afterwards transferred to the banks of the Ioâo de Tyba, four miles to the northward, no doubt from this site holding out greater advantages of soil. Besides this place, Tourinho founded the town of St. Amaro, three miles to the south of Porto Seguro, which was subsequently demolished by some of the Indian tribes. After passing through various hands, this captaincy ultimately reverted to the crown in 1758. It was then in a very wretched state, and contained only two towns. The Jesuits, with all their zeal, were able to effect but little, and at the time of their expulsion, they left only two aldeias entirely Indian. As early as 1553, they founded a college in the capital, with a view to prosecute their labours amongst the Indians of the province, but, as in the case of Espiritu-Santo, with very little success.

The Rio Doce, or sweet river, the most considerable stream between Rio and Bahia, has its origin in the mountains of Minas Geraes, and assumes the name which it bears after the confluence of the Rio Piranga with the Ribeiro do Carmo. It runs through a considerable tract of country, forming several falls in its course. The banks of this river are covered with thick forests, which are the haunt of a great number of different animals. But far more formidable than all those beasts of prey, and the terror of these forests, is the savage Botucudo, the original inhabitant of the country. Some stations have, from time to time, been formed on the beautiful banks of the Doce; but they have never thriven, from being liable to attacks by the savages, so that the country is still very thinly peopled, and no communication is kept up except along the river. From the banks of the Rio Doce to the St. Matthæus, a dreary uninhabited wilderness extends along the coast. Indeed, for more than a hundred miles the maritime district is a very flat tract of country; the dull monotony which it presents being only here and there relieved by a sheet of water, or small mountain elevation. The district of St. Matthæus contains about 3000 inhabitants, who cultivate a great deal of mandioc, and export annually 60,000 alquieres of flour, and also planks from the neighbouring forests. The orange, the lemon, and the water-melon, flourish here luxuriantly.

Ports-mouth.

and of the harbour above the town, become worthy of observation and description. One of the great advantages of this place is that very fine anchorage known by the name of Spithead. It is about half way between the mainland and the Isle of Wight, but nearer to the latter. It is protected by the high land of the island from southerly winds, and from northerly and easterly winds by the mainland. It has an advantageous entrance. For, though at the east there are some dangers on what is called the Princessa shoal, and on the ranges of rocks called Bambridge's Ledge, and Betty's Ledge, they, as well as the Nab rock, the Long rock, the Warner, and Romansland, are so well provided with either floating lights or distinguishing buoys, that there is little risk, except in those very thick fogs when the buoys cannot be seen, nor the leading marks observed on the sea-shore. At this entrance it is a great advantage, that at St. Helen's, at the east end of the island, there is a good anchorage, so that if the wind takes a vessel short, she can safely ride till the breeze is in her favour. The western entrance to Spithead is by Hurst Castle, and the rocks called the Needles. This passage is always safe in fair winds, on account of the definite track which is shewn by the buoys, lights, and landmarks; but it is so hazardous, that few ships attempt in a contrary wind to beat through. The passage out by the Needles is used by more vessels than come into Spithead that way.

The anchoring ground at Spithead is very good for holding, and very clear, except near the wrecks of the Royal George, the Boyne, and the Edgar, around which the tide has formed considerable banks. There is a regular depth of water in every part, varying from six to twelve fathoms, and the space is sufficient for the whole navy of England to ride at single or double anchor, without danger of falling on board each other when swinging with the changes of the tide.

Within the smooth water, between the island and the mainland, there are other very good anchorages, besides that of Spithead. The Mother-bank is one of them, which, though there are but two fathoms of water at low tides, has near to the bank from seven to nine fathoms, where in time of war merchant ships have been collected to wait for the convoy of ships of war. Stakes Bay is another anchorage, where there is from four to nine fathoms water, and where merchant ships often anchor.

The great advantages arising from so secure a rendezvous as Spithead, so near to the great national marine arsenal, are too obvious to need any elaborate remarks. The entrance to the harbour of Portsmouth is very narrow, but with sufficient depth of water for the largest ships. The channels by which vessels approach the mouth of the harbour, are commanded by batteries of such power that an enemy's fleet, however strong, would be annihilated before it could reach even the entrance. Within the narrow gut at the entrance, on one side of which is Portsmouth, and on the other side Gosport, the water spreads out into a wide basin, in which those ships of war that are under repair, or preparing for sea, are riding, and some of them lying at the wharfs of the dock which borders the harbour on the eastern side. From thence the harbour extends into the land, and contains, in one part called Rotten Row, the ships that are in ordinary, being with no other crew but a few warrant officers, to prevent them from plunder, or from injury by weather. The water here branches off in various directions, and by the help of the tide is navigable to Farnham, and to Porchester Castle, a pile of antiquity that will reward the curiosity of a visitor.

The dock-yard of Portsmouth is one of those noble objects in which every Briton feels an interest. But this has already been described under the article Dock Yards.

The gun wharf, under the ordnance department, is an immense arsenal, consisting of various ranges of buildings for the reception of military and naval stores and artillery. Some of the storehouses are vast piles, especially two, which, with their dependencies, are fitted to contain all kinds of necessaries for the sudden equipment both of a fleet and an army. On the wharf is the grand depôt for guns, carronades, and mortars, with shot and shells of almost every weight and size, all of which are arranged in immense pyramids. Here also in time of peace the guns from the ships in ordinary at the port are lodged, each ship's guns being kept in a separate tier, whilst the carriages are deposited away in the same regular manner in the proper storehouses, so that the whole may be easily collected again and re-embarked. The small armoury is a spacious building, and the great object of admiration. Within it are upwards of 20,000 stand of arms, all placed in the same ornamental style as those of a similar description in the tower of London. The roof of this building is covered with copper, which being oxydized by exposure to the atmosphere, when viewed on approaching it from the quay gate, conveys to the mind the idea of a green glassy slope, or a still wave of the sea.

The victualling establishment has recently been removed from Portsmouth to the opposite side of the harbour, and properly belongs to the town of Gosport. The expense of this depository is said to have amounted to half a million of money. The storehouses, of vast dimensions, are used as depositories for bread, beef, pork, and other articles of food, of rum, wine, and clothing, that are kept ready for the supply of the navy. A special object of curiosity at this establishment is the machinery substituted for manual labour in making biscuit, whereby every process, in its minutest detail, is effected, preparatory to its being ready for the oven, including kneading, rolling, forming, and stamping. Another object worthy of attention is a fine new steam corn mill, recently built an an expence of L.76,000.

Portsmouth is not merely a port for warlike purposes, but enjoys a considerable foreign and coasting trade. The custom-house is a large and convenient building, and in its stores merchandize may be kept under bond free of duty till it is sold for internal consumption, or is exported. The shipping belonging to the port, in which Gosport is included, consists of about 300 sail of vessels, registered at nearly 10,000 tons; some are engaged in the Newfoundland fishery, and since the trade with India has been laid open, a few vessels have landed cargoes here from beyond the Cape of Good Hope. There is a considerable importation of wine, and some of West India articles, but the chief business consists in timber, corn, Irish provisions, Spanish and Portuguese fruits, and the vine of both these countries. The amount of duty annually received on imported articles at the custom-house, is from L.50,000 to L.60,000.

Portsoy.

PORTSOY, a burgh of barony and a sea-port town, in the parish of Fordyce, and county of Banff. It is situated on a point of land, jutting into a small bay, of the same name, on the Moray Frith, and consists of a few streets, irregularly built. The harbour is small, but safe, and is capable of admitting vessels of 150 tons. The chief trade is in linen and thread, manufactured principally for the Aberdeen, London, and Nottingham trade. Grain is also shipped from the port, and there is a considerable trade arising from the herring fishing. Portsoy is famed for the serpentine, erroneously called Portsoy marble, which is quarried to a considerable extent near the town. It is beautifully variegated, and as it is susceptible of a high polish, it is much used for ornaments. There is also found the splendid variety of flesh-coloured granite, possessing Labrador feldspar, which is nowhere else to be found, except in Arabia, where it was first discovered. The population in 1821 amounted to 1,700, and in 1831, the population of the parish and burgh was 3,364.

History.

they had nothing farther in view than to explore those parts of the coast of Africa which lay nearest to their own country. But a spirit of enterprise, when roused and put in motion, is always progressive; and that of the Portuguese, though slow and timid in its first operations, gradually acquired vigour, and prompted them to advance along the western shore of the African continent far beyond the utmost boundary of ancient navigation in that direction. Encouraged by success, they became more adventurous, despised dangers which formerly appalled them, and surmounted difficulties which were once deemed insuperable. When the Portuguese found in the torrid zone, which the ancients had pronounced to be uninhabitable, fertile countries, occupied by numerous nations, and perceived that the continent of Africa, instead of extending in breadth towards the west, according to the opinion of Ptolemy, appeared to contract itself, and to bend eastwards, more extensive prospects opened to their view, and inspired them with hopes of reaching India, by continuing to hold the same course which they had so long pursued.

Circumstances which facilitated the discovery.

After several unsuccessful attempts to accomplish what they had in view, a small squadron sailed from the Tagus, under the command of Vasco de Gama, an officer of rank, whose abilities and courage fitted him to conduct this difficult and arduous enterprise. From ignorance, however, of the proper season and route of navigation in that vast ocean through which he had to steer his course, his voyage was long and dangerous. At length he doubled that promontory which had been descried by Diaz, and which, for several years, had been the object of terror and of hope to his countrymen. After a prosperous navigation along the south-east coast of Africa, he arrived at the city of Melinda, and had the satisfaction of discovering there, as well as at other places where he touched, people of a race very different from the rude inhabitants of the western shore of that continent, which alone the Portuguese had hitherto visited. These he found to be so far advanced in civilization and acquaintance with the various arts of life, that they carried on an active commerce, not only with the nations on their own coast, but with remote countries of Asia. Conducted by their pilots, who held a course with which experience had rendered them well acquainted, he sailed across the Indian ocean, and landed at Calicut, on the coast of Malabar, on the 22d of May 1498, ten months and two days after his departure from the port of Lisbon. (See the article GAMA.)

The king of the country jealous of his new visitors.

The samorin or monarch of the country, astonished at this unexpected visit of an unknown people, whose aspect, and arms, and manners, bore no resemblance to those of any of the nations accustomed to frequent his harbours, and who arrived in his dominions by a route hitherto deemed impracticable, received them at first with that fond admiration which is often excited by novelty; but in a short time, from whatever motives, he formed various schemes to cut off Gama and his followers. The Portuguese admiral, however, was not to be overreached by such politics as his. From every danger to which he was exposed, either by the open attacks or secret machinations of the Indians, he extricated himself with singular prudence and dexterity, and at last sailed from Calicut with his ships, loaded not only with the commodities peculiar to that coast, but with many rich productions of the eastern parts of India. He returned to Portugal in two years after his sailing from the Tagus, but with a great loss of men; for out of one hundred and forty-eight persons who sailed with him, only fifty-five returned. The king received him with all possible testimonies of respect and kindness; created him Count of Videgueira; and not only declared him admiral of the Indies, but also made that office hereditary in his family.

The Portuguese entered upon the new career opened to them with activity and ardour, and made exertions, both commercial and military, far beyond what could have been expected from a kingdom of such inconsiderable extent. All these were directed by an intelligent monarch, capable of forming plans of the greatest magnitude with systematic wisdom, and of prosecuting them with unremitting perseverance. The prudence and vigour of his measures, however, would have availed but little without proper instruments to carry them into execution. Happily for Portugal, the discerning eye of Emanuel selected a succession of officers to take the supreme command in India, who, by their enterprising valour, military skill, and political sagacity, accompanied with disinterested integrity, public spirit, and love of their country, have established a title to be ranked amongst the persons most eminent for virtue and abilities in any age or nation. Greater things perhaps were achieved by them than were ever accomplished in so short a time. Within twenty-four years after the voyage of Gama the Portuguese had rendered themselves masters of the city of Malacca, in which the great staple of trade carried on amongst the inhabitants of those regions in Asia which Europeans have distinguished by the general name of the East Indies, was then first established. This conquest secured to them great influence over the interior commerce of India, whilst, at the same time, by their settlements at Goa and Diu, they were enabled to engross the trade of the Malabar coast, and to obstruct greatly the long-established intercourse of Egypt with India by the Red Sea. In every part of the East they were received with respect; in many they had acquired the absolute command. They carried on trade there without rivalry or control; they prescribed to the natives the terms of their mutual intercourse; they often fixed what price they pleased on the goods which they purchased; and they were thus enabled to import from Hindustan, and the regions beyond it, whatever was useful, rare, or agreeable, in greater abundance, and of more various kinds, than had been formerly known in Europe.

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The settlement of the Portuguese in India.

Opposition made by the Venetians.

Not satisfied with this ascendant which they had acquired in India, the Portuguese early formed a scheme not less bold than interested, of excluding all other nations from participating in the advantages of commerce with the East; and they accomplished one half of what their ambition had planned. In consequence of this the Venetians soon began to feel that decrease of their own Indian trade which they had foreseen and dreaded. In order to prevent the farther progress of this evil, they incited the soldan of the Mamlukes to fit out a fleet in the Red Sea, and to attack those unexpected invaders of a gainful monopoly, of which he and his predecessors had long enjoyed undisturbed possession. The Portuguese, however, encountered his formidable squadron with undaunted courage, entirely defeated it, and remained masters of the Indian Ocean. They continued their progress in the East almost without obstruction, until they established there a commercial empire; to which, whether we consider its extent, its opulence, the slender power by which it was formed, or the splendour with which the government of it was conducted, there had hitherto been nothing comparable in the history of nations. Emanuel, who laid the foundation of this stupendous fabric, had the satisfaction to see it almost completed. Every part of Europe was supplied by the Portuguese with the productions of the East; and if we except an inconsiderable quantity which the Venetians still continued to receive by the ancient channels of conveyance, our quarter of the globe had no longer any commercial intercourse with India, and the regions of Asia beyond it, except by the Cape of Good Hope.

Inquisition introduced into Portugal.

In September 1522, King Emanuel died of an epidemical fever, and was succeeded by his son John III. The most remarkable transaction of this prince's reign was the introduction of the inquisition into his dominions. This happened in the year 1525, or, as some say, in 1535. A famine happening to cease in a short time after the Holy Office was introduced, the priests persuaded the ignorant multitude that

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it was a blessing from heaven on account of erecting such a tribunal. It was not long, however, before the bulk of the nation perceived what kind of a blessing the inquisition had conferred. But their discernment came too late; for by that time the inquisitors had acquired such power, that it became equally ineffectual and dangerous to attempt disclosing any of their mysteries.

Solyman the Magnificent. Conduct and policy of the Portuguese.

In the mean time Solyman the Magnificent, the most enlightened monarch of the Ottoman race, observing the rising power and opulence of the Portuguese, attributing it to its proper cause, and eager to supplant them, sent orders to the pasha of Egypt to employ his whole strength against the Christians in the East Indies. The pasha, in obedience to these orders, sailed from the Red Sea with a greater naval force than ever the Mahommedans had employed before, having four thousand Janizaries and sixteen thousand other troops on board. Yet, by the courage and conduct of the Portuguese officers and soldiers, all this mighty armament was defeated, and their East India possessions were saved from the danger which threatened them. In Africa, likewise, the king of Fez was baffled before the town of Safi, whilst fresh quarrels breaking out amongst the native princes, gave great relief to the Christians, who had long been obliged to carry on a defensive war, and had more than once been on the very brink of ruin. For a long time indeed their safety had depended solely on the quarrels of the Moors amongst themselves; for such were the envy and jealousy which reigned amongst the Portuguese, that they could never combine heartily in opposing the common enemy; and therefore, had their enemies united against them, they must certainly have been cut off. But whenever the scheriffs quarrelled with each other, one party was sure to have recourse to the Portuguese, who, by sending them a small supply, secured quiet to themselves, and had the pleasure of seeing their enemies destroy one another. Yet in the end even this had bad consequences. For, on the one hand, it kept up a martial spirit amongst the Moors, and on the other it made them acquainted with the Portuguese discipline; so that after every short interval of repose, they not only found them as much enemies as before, but more formidable than ever. The consequence of all this was, that King John began to apprehend that the conquest of Barbary was impossible, and therefore limited his ambition to keeping those few fortresses which he had already acquired; a necessary and prudent measure, which nevertheless displeased the generality of his subjects.

Brazil.

King John exerted himself greatly in the settlement of Brazil in South America, which he brought into a good state, caused several strong towns to be erected there, and took all possible methods to encourage the conversion of the natives to Christianity. He also introduced many regulations for the welfare and happiness of his subjects. The disputes of the nobility about precedency were frequently attended with disagreeable consequences, which made the king resolve to settle them definitively by established rules; and the principles established by him on this occasion have subsisted ever since, and serve in a great measure to prevent such altercations. He had also other designs in his mind, particularly with regard to the reformation of religious persons of both sexes; but, on a close examination of his affairs, he found that his subjects in general had been so much injured by his leaving their concerns to the inspection of his council, that he was thrown by grief into a kind of apoplexy, from which he never recovered. His death happened in June 1557; and he was succeeded by his son Dom Sebastian III. an infant of three years of age.

Education of the young king.

After the death of King John, the administration remained in the hands of the queen, grandmother of Sebastian, who behaved with great prudence and circumspection. The Moors, however, supposing that under a minority they might be able to dispossess the Christians of such places as they held in Barbary, laid close siege to Masagan. But the queen regent speedily sent succours, and promised such rewards to those who distinguished themselves, that the Moors, although they brought eighty thousand men into the field, were obliged to abandon the enterprise. This was at first magnified as a conspicuous instance of the queen's capacity and wisdom; but, in a short time, the natural aversion which the Portuguese have to the government of women, together with the prejudice they had conceived against her country, as being a Castillian, appeared so plainly, and gave her so much uneasiness, that of her own accord she resigned her authority into the hands of Cardinal Dom Henry, the king's brother. Dom Alexis de Moneses was now appointed the governor to the king, and Gonsales de Gomera and two other priests his preceptors. By these instructors the king's education was totally marred. His governor assiduously inculcated upon his mind that the chief virtue of a king was courage, and that danger was never to be avoided, but always surmounted; whilst his other tutors, instead of instructing him in the true religion, only inspired him with an abhorrence of professed infidels. The consequence was, that he became rash, inconsiderate, and obstinate, displaying all those qualities that conspired to draw upon him the catastrophe which ruined both him and the kingdom.

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Sebastian undertakes an expedition against Africa.

After the king had grown up to man's estate, his desire was to distinguish himself against the infidels. He himself intended to conduct an expedition to the East Indies; but the prime minister Alcoçova, who did not choose to attend his monarch to such a distance, substituted Africa in its stead. This expedition the king entered into in the most inconsiderate and absurd manner. He first sent for Dom Antonio, prior of Crato, with some hundreds of soldiers; next he carried his principal courtiers with him from a hunting match, and without equipages; he then sent for the Duke of Aveyro, who brought with him such troops as he could collect on so short a warning; and when all these were assembled, the king spent his time in hunting, and slight excursions against the enemy, without doing any thing of consequence, except exposing his person upon all occasions. At length he returned to Portugal in tempestuous weather, and his unexpected arrival was celebrated with the greatest rejoicings.

The trifling success which had attended the king in this expedition served only to inflame him with a greater desire for another; and from the time of his return he seemed to think on nothing else. He was highly delighted also with an accident which furnished him with a pretence for war, of which, however, he stood in no great need. Muley Hamet, king of Fez and Morocco, had been dispossessed of his dominions by his uncle Muley Moloch. At the beginning of this war Dom Sebastian had offered him the Portuguese troops in Africa, a tender which was rejected with contempt; but now being a fugitive, and having in vain solicited assistance from Philip of Spain, Muley Hamet applied to the king of Portugal; and, that he might the more easily succeed, he caused the fortress of Arzila, which his father had recovered, to be restored to the Portuguese. The king was in rapture at this event, and fancied that his glory would exceed that of all his predecessors. He was, however, dissuaded against engaging in this expedition by all his friends. Philip of Spain, having done everything to dissuade him at a personal conference, sent Francisco Aldana, an old and experienced officer, to Morocco; and, at his return, ordered him to attend Dom Sebastian, in order to give him an account of the state of affairs in that country. This he performed with the greatest fidelity, but without any effect. The queen-dowager and the cardinal united in their endeavours to divert him from this unfortunate enterprise; but he treated them both with so little respect that his grandmother broke her heart; and the cardinal, to show his distaste of the measure, retired to Evora without coming either to court or to council, an example which was followed by many of the nobles. Many of these, however, transmitted remonstrances

History. to the king on the impropriety of his conduct; and Philip sent to him the Duke de Medina Celi to lay before him once more the reasons why he thought his scheme impracticable, and to put him in mind that he had no hand in pushing him upon his destruction, or of concealing from him the dangers into which he seemed determined to plunge himself and his subjects. Lastly, he received a letter on the subject from Muley Moloch himself, in which that prince explained to him his own right to the crown of Fez, and showed that he had only dispossessed a tyrant and a murderer, who had therefore no right to his friendship or assistance. The Moorish prince next assured him that he had no reason to fear either the power or the neighbourhood of the Portuguese; and as a proof of this, as well as a mark of his esteem, he was content to make him a present of some ten miles of arable ground round each of the fortresses he possessed in Africa, viz. Tangier, Ceuta, Masagan, and Arzila. At the same time, he addressed himself to Philip king of Spain, with whom he was on good terms, desiring him to interpose with his nephew Sebastian, that things might yet be adjusted without the effusion of human blood. But the king of Portugal was deaf to all salutary advice; and therefore paid no regard to this letter, nor to the remonstrances of his uncle.

New expedition to Africa. On the 24th of June 1577, he set sail from the bar of Lisbon with a fleet of fifty ships and five galleys, twelve pieces of cannon, and many transports and tenders, making in all near a thousand sail. His troops consisted of nine thousand Portuguese infantry; three thousand Germans; seven hundred Italians, commanded by Sir Thomas Stukeley, an English exile, remarkable for his bravery; two thousand Castillians and three hundred volunteers, commanded by Dom Christoval de Tuvara, master of the horse, a man of courage, but without either conduct or experience. He touched first at Lagos Bay in the kingdom of Algarve, where he remained for four days; and thence he proceeded to Cadiz, where he was magnificently feasted for a week by the Duke de Medina Sidonia, who once more endeavoured to dissuade him from proceeding further in person. But this exhortation proved as fruitless as the rest; and the king having sailed with a strong detachment for Tangier, ordered Dom Diego de Souza, the commander-in-chief, to follow with the remainder of the army.

The troops landed on the coast of Africa without any accident, and joined at Arzila. Here the king was met by the Scheriff Muley Hamet, on whose account he had undertaken the war, who delivered him his son Muley, a boy of twelve years of age, as a hostage, and brought a reinforcement of three hundred Moors. The boy was sent to Masagan under a strong guard; but the father remained in the Portuguese camp. Here it was resolved in a council of war to reduce the town of Larache, but it was disputed whether the troops should proceed thither by land or by sea. Don Sebastian, who espoused the former opinion, finding himself opposed by Muley Hamet, answered him so rudely that he left his presence in disgust; after which the king's opinion prevailed, and the army began its march on the 29th of July. As they proceeded, the king received a letter from the Duke of Alba, requesting him to attempt nothing beyond the taking of the town of Larache. Along with the latter was sent an helmet which had been worn by Charles V.

Movements and dispositions of the armies. On the other hand, Muley Moloch, having received intelligence of this formidable invasion, took the field with forty thousand foot and sixty thousand horse, and conducted everything with the greatest prudence, notwithstanding he was so enfeebled by fever that he could not sit upon horseback. Finding reason to suspect that part of his army were desirous of going over to his rival, he proclaimed that such as inclined to join their old master were at liberty to do so. This at once put a stop to the defection, and only a few availed themselves of the liberty which was granted them. Being likewise doubtful of the fidelity of a body of three thousand horse, he sent them to reconnoitre the enemy, by which act of confidence he secured them. Still, however, fearing that his officers might be corrupted by Portuguese gold, he entirely changed the disposition of his army, so that none of his officers commanded the corps to which they had been accustomed, and having new men to deal with, had none in whom they could confide. History.

Having taken these precautions, he advanced against the Portuguese army with such celerity that he came in sight of them on the 3d of August. On this Dom Sebastian called a council of war, in which many who out of complaisance had declared for this march, were now for returning. They were separated from the enemy by a river, but the Moors being masters of the ford, it was impossible to force them immediately from their post; neither was it practicable for them to wait for a more favourable opportunity, because they had no provisions. The foreign officers, on the contrary, were of opinion that fighting had now become necessary, and a retreat dangerous. This, however, was violently opposed by the scheriff, who saw plainly that they ran a great risk of being defeated, and of losing all, whilst, at the same time, they were not certain of gaining any thing of consequence should they prove victorious; whereas, if they withdrew towards the sea, they might entrench themselves till they were relieved by their fleet; and during this interval, if Muley Moloch should die, he looked upon it as certain that a great part of the army would desert to him, which would render him master not only of the kingdom, but of the fate of the Christians also. When he found that the king was bent upon fighting, he only requested that the engagement might be delayed till four o'clock in the afternoon, that, in case of a defeat, they might have some chance of escaping. But even in this he could not prevail; for the king having disposed everything for a battle the next day, was impatient to begin the onset as soon as it was light.

In the mean time, Muley Moloch was so sensible of the advantages of his situation, that he was inclined to take the whole Portuguese army prisoners; but finding his disease increase to such a degree that he had no hopes of recovery, he came to the resolution to fight, that his antagonist might not avail himself of his death. The disposition of the Christian army was, through the care of some old officers in Don Sebastian's service, regular and correct. The infantry were disposed in three lines; the battalion of volunteers formed the vanguard; the Germans, commanded by Colonel Amberg, and the Italians by Sir Thomas Stukeley, were stationed on the right; the Castillian battalions occupied the left, and the Portuguese were in the centre and rear; the cavalry, consisting of about fifteen hundred men, being partly on the right, under the command of the Duke d'Avegro, to whom the scheriff joined himself with his horse. On the left was the royal standard, with the rest of the cavalry, under the command of the Duke of Barcelos, eldest son of the Duke of Braganza, Dom Antonio, prior of Crato, and several other persons of rank. The king took post at first with the volunteers. Muley Moloch also disposed his troops in three lines. The first consisted of the Andalusian Moors, commanded by three officers who had distinguished themselves in the wars of Granada; the second was composed of renegadoes; and the third consisted of the natives of Africa. They were formed in a crescent, with ten thousand horse on each wing, and the rest in the rear, with orders to extend themselves in such a manner as to encompass the Christian army. Muley Moloch, though extremely weak, was taken out of his litter, and set on horseback, that he might see how his commands had been obeyed; and being perfectly satisfied with the situation of his troops, he directed the signal of battle to be given.

The Christians advanced with the greatest resolution, broke the first line of the Moorish infantry, and disordered the second. On this Muley Moloch drew his sword, and would

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The Portuguese army entirely defeated.

have advanced to encourage his troops; but his guards prevented him, on which his emotion of mind became so great that he fell from his horse. One of his guards caught him in his arms, and conveyed him to his litter, where he immediately expired, having only time to lay his finger on his lips by way of enjoining them to conceal his death. But by this time the Moorish cavalry had wheeled quite round, and attacked the Christian army in the rear; upon which the cavalry in the left wing made such a vigorous effort that they broke the Portuguese on the right; and at this time the scheriff, in passing a rivulet, was drowned. In this emergency, the Germans, Italians, and Castillians, performed prodigies; but the Portuguese, according to their own historians, behaved indifferently. Attacked on all sides, however, they were unable to resist; and the whole army, except about fifty men, were killed or taken prisoners. The fate of the king is variously related. According to some, he had two horses killed under him, and then mounted a third. His bravest officers were killed in his defence; after which the Moors surrounding him, seized his person, stripped him of his sword and arms, and secured him. They immediately began to quarrel about the prisoner, upon which one of the generals rode in amongst them, crying, "What, you dogs, when God has given you so glorious a victory, would you cut one another's throats about a prisoner?" At the same time, discharging a blow at Sebastian, he brought the king to the ground, when the rest of the Moors soon despatched him. Others affirm, that one Louis de Brito meeting the king with the standard wrapped round him, Sebastian cried out, "Hold it fast; let us die upon it;" upon which, charging the Moors, he was seized, but rescued by Brito, who was himself taken with the standard and carried to Fez. The latter affirmed, that after he was taken, he saw the king at a distance, and unpursued. Dom Louis de Lima met him afterwards making towards the river; and this is the last account of his being seen alive.

Portugal conquered by Philip of Spain.

Immediately after the battle, Muley Hamet, the brother of Muley Moloch, was proclaimed king by the Moors. The next day, having ordered all the prisoners to be brought before him, the new sovereign gave orders to search for the body of Dom Sebastian. The king's valet-de-chambre brought back a body, which he said was that of his master, but so disfigured with wounds that it could not well be known; and, notwithstanding the most diligent search, this monarch's death could never be properly authenticated. This body, however, was preserved by Muley Hamet, who delivered it up as the body of the unfortunate Dom Sebastian to Philip king of Spain. By the latter it was sent to Ceuta, thence transported to Portugal, and buried amongst his ancestors in the monastery at Belem, with all possible solemnity.

By this disaster, the kingdom of Portugal, from being the most eminent, sunk at once into the lowest rank of the European states. All the young nobility were cut off or carried into slavery, and the kingdom was exhausted of men, money, and reputation; so that Dom Henry, who assumed the government after the death of his brother Dom Sebastian, found himself in a very disagreeable situation. The transactions of his reign were trifling and unimportant; but after the death of the king a great revolution took place. The crown of Portugal was claimed by three different competitors, viz. the Prince of Parma, the Duchess of Braganza, and Philip of Spain. Whatever might have been the merits of their respective claims, the power of Philip quickly decided the contest in his favour. He found his schemes facilitated by the treachery of the regents, who took the most scandalous methods of putting the kingdom into his hands. Under pretence of inspecting the magazines, they withdrew some of the powder, and mixed the rest with sand; they appointed an agent to repair for succours to France, whence they knew that they could not arrive in time; they dissolved the states as soon as they discovered that they were bent upon maintaining the freedom of the nation; and, under a show of confidence, they sent off to distant places such of the nobility as they suspected. History.

Philip finding everything in his favour, commanded the Duke of Alva to invade Portugal at the head of twenty thousand men. The people, perceiving that they were betrayed, exclaimed against the governors, and placed on the throne Don Antonio, prior of Crato. But his forces being inexperienced, and his own conduct indifferent, he was quickly defeated by the Duke of Alva, and forced to leave the kingdom. On his flight the whole kingdom submitted, together with the garrisons of Barbary, and also the settlements upon the coast of Africa, in Brazil, and in the East Indies. The Madeiras, however, excepting the isle of St Michael, held out for Don Antonio until they were reduced, and the French navy, which came to their assistance, entirely defeated and destroyed.

Terms granted by him to his new subjects.

Philip made his entry into Lisbon as soon as the kingdom had been totally reduced, and endeavoured to conciliate the affections of the people by confirming the terms which he had before offered to the states. These terms were, that he would take a solemn oath to maintain the privileges and liberties of the people; that the states should be assembled within the realm, and nothing proposed in any other states that related to Portugal; that the viceroy or chief governor should be a native, unless the king should give that charge to one of the royal family; that the household should be kept on the same footing; that the post of first president, and all offices, civil, military, and judicial, should be filled by Portuguese, all dignities in the church and in the orders of knighthood confined to the same, the commerce of Ethiopia, Africa, and the Indies, reserved also to them, and to be carried on only by their merchants and vessels; that he would remit all imposts on ecclesiastical revenues; that he would make no grant of any city, town, or jurisdiction royal, to any but Portuguese; that estates resulting from forfeitures should not be united to the domain, but go to the relations of the last possessor, or be given to other Portuguese in recompense of services; that when the king came to Portugal, where he should reside as much as possible, he should not take the houses of private persons for his officers' lodging, but keep to the custom of Portugal; that wherever his majesty resided, he should have an ecclesiastic, a treasurer, a chancellor, two masters of requests, with inferior officers, all of them Portuguese, who should despatch everything relating to the kingdom; that Portugal should ever continue a distinct kingdom, and its revenue be consumed within itself; that all matters of justice should be decided within the realm; that the Portuguese should be admitted to charges in the households of the king and queen of Spain; that all duties on the frontiers should be taken away; and, lastly, that Philip should give three hundred thousand ducats to redeem prisoners, repair cities, and relieve the miseries which the plague and other calamities had brought upon the people. All these conditions, formerly offered and rejected by the Portuguese, the king now confirmed; but although the Duke of Ossuna, by way of security, had promised them a law, that if the king did not adhere to them, the states should be freed from their obedience, and might defend their right by the sword, without incurring the reproach of perjury or the guilt of treason, this he absolutely refused to ratify.

All these concessions, however, failed to answer the purpose; nay, although Philip was to the last degree lavish of honours and employments, the Portuguese were still dissatisfied. This had also an effect which was not foreseen. It weakened the power and absorbed the revenues of the crown; and, by putting it out of the power of any of his successors to be liberal in the same proportion, it raised only a short-lived gratitude in a few, and left a number of malcontents, to which time was continually adding.

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Thus Philip, with all his policy and endeavours to please, found his new subjects still more and more disgusted with his government, especially when they found their king treating with the utmost severity all those who had supported Don Antonio. The exiled prince, however, still styled himself, "king of Portugal." At first he retired to France, and there demanded succours for the recovery of his dominions. Here he found so much countenance, that with a fleet of nearly sixty sail, and a considerable body of troops on board, he made an attempt upon Terceira, where his fleet was beaten by the Spaniards, and many prisoners being taken, all the officers and gentlemen were beheaded, and a great number of meaner people hanged. Dom Antonio, however, kept possession of some places, coined money, and performed many other acts of sovereign power; but he was at length constrained to retire, which he did with some difficulty, and returning into France, he passed thence into England, where he was well received; and many fitted out privateers to cruize against the Spaniards under his commission. But after Philip had ruined the naval power of Portugal as well as that of Spain, by equipping the Armada, Queen Elizabeth made no difficulty of owning and assisting Dom Antonio, and even of sending Sir John Norris and Sir Francis Drake with a strong fleet and a considerable army to restore him. Upon this occasion Don Antonio sent his son Don Christoval a hostage to Muley Hamet, king of Fez and Morocco, who was to lend him two hundred thousand ducats. But Philip prevented this by surrendering Arzila; which, with the unseasonable enterprise against Corunna, and the disputes that arose between Norris and Drake, rendered the expedition abortive; so that, except carrying the plague into England, it was attended with no consequences worthy of notice. Dom Antonio remained some time afterwards in England; but finding himself disregarded, he withdrew once more into France, where he fell into great poverty and distress; and having at length died in the sixty-fourth year of his age, his body was buried in the church of the nuns of Ave Maria, with an inscription on his tomb, in which he is styled, "king." He left behind him several children, who, on account of his being a knight of Malta, and having made a vow of chastity at his entrance into the order, were looked upon as illegitimate.

Treatment of Dom Antonio.

Impostors pretending to be Dom Sebastian.

But Dom Antonio was not the only pretender to the crown of Portugal. The people, partly from love of their prince, and partly from their hatred to the Castillians, were continually feeding themselves with the hopes that Dom Sebastian would appear and deliver them; and in this respect such a spirit of credulity reigned, that they would probably have taken a negro for Dom Sebastian. This humour induced the son of a tiler at Alcobaça, who had led a profligate life, and at length turned hermit, to give himself out as that prince; and having with him two companions, one of whom styled himself Dom Christoval de Tavora, and the other the bishop of Guarda, they began to collect money, and were in a fair way of creating much disturbance. But the cardinal archduke caused them to be apprehended, and after leading them ignominiously through the streets of Lisbon, he who took the name of Sebastian was sent to the galleys for life, and the pretended bishop was hanged. Not long afterwards, Gonsalo Alvarez, the son of a mason, gave himself out as the same king, and having promised marriage to the daughter of Pedro Alonso, a rich yeoman, whom he created count of Torres Novas, he assembled a body of about eight hundred men, and some blood was spilt before he was apprehended. At length, being clearly proved to be an impostor, this person and his intended father-in-law were publicly hanged and quartered at Lisbon. The punishment, however, instead of extinguishing public credulity, served only to increase it.

A remarkable knave.

About twenty years after the fatal defeat of Sebastian, there appeared at Venice a person who created much more trouble. He assumed the name of Don Sebastian, and gave a very distinct account of the manner in which he had passed his time since that defeat. He affirmed, that he had preserved his life and liberty by hiding himself amongst the slain; that, after wandering in disguise for some time in Africa, he returned with two of his friends into the kingdom of Algarve; that he gave notice of this to the king Don Henry; that finding his life sought, and being unwilling to disturb the peace of the kingdom, he returned again amongst the Moors, and passed freely from one place to another in Barbary, in the habit of a penitent; and that after this he became a hermit in Sicily, but at length resolved to go to Rome, and discover himself to the pope. On the road he was robbed by his domestics, and came almost naked to Venice, where he was known and acknowledged by some Portuguese. Complaint, however, being made to the senate, he was obliged to retire to Padua. But as the governor of that city also ordered him to depart, he, not knowing what to do, returned to Venice, where, at the request of the Spanish ambassador, who charged him not only with being an impostor, but also with many black and atrocious crimes, he was seized, and thrown into prison. He underwent, before a committee of noble and impartial persons, twenty-eight examinations, in which he not only acquitted himself clearly of all the crimes which had been laid to his charge, but entered into so minute a detail of the transactions which had passed between himself and the republic, that the commissioners were perfectly astonished; and, moved by the firmness of his behaviour, his singular modesty, the sobriety of his life, his exemplary piety, and his admirable patience under affliction, they showed no disposition to declare him an impostor. The noise of this was diffused throughout Europe, and the enemies of Spain endeavoured everywhere to give it credit.

The state, however, refused to discuss the point, whether he was or was not an impostor, unless they were requested so to do by some prince or state in alliance with them. Upon this the Prince of Orange sent Dom Christoval, the son of the late Dom Antonio, to make that demand; and at his request an examination was instituted with great solemnity. But no decision followed; only the senate set him at liberty, and ordered him to depart from their dominions in three days. By the advice of his friends, therefore, he proceeded to Padua in the disguise of a monk, and from thence to Florence, where he was arrested by the command of the grand duke, who delivered him up to the viceroy of Naples. He remained several years prisoner in the castle Del Ovo, where he endured incredible hardships. At length he was brought forth, led with infamy through the streets of the city, and declared to be an impostor, who assumed the name of Sebastian; at which words he said gravely, "And so I am." In the same proclamation it was affirmed that he was in truth a Calabrian; but as soon as he heard this he said, "It is false." He was next shipped on board a galley as a slave, and carried to San Lucar, whence, after being for some time confined there, he was transferred to a castle in the heart of Castille, and never heard of more. Some persons were executed at Lisbon for their endeavours to raise an insurrection in his behalf; but it was thought strange policy, or rather a strange want of policy, in the Spaniards, to make this affair so public without proofs; and the attempt to put down the objection, by affirming that he was a magician, justly excited ridicule and contempt.

Bad consequences of the Spanish administration.

The administration of affairs in Portugal, during the reign of Philip, was certainly detrimental to the nation; and yet it does not appear that this proceeded so much from any ill intention in that monarch, as from errors in judgment. His prodigious preparations for the invasion of England impoverished all his European dominions; but it absolutely exhausted Portugal. The pretensions of Dom

History. Antonio, and the hopes of despoiling their Indian fleets, exposed the Portuguese to the resentment of the English, from which the king wanted power to defend them. Their clamours were not the less loud for their being in some measure without cause. The king, in order to pacify them, borrowed money from the nobility upon the customs, which was the only remedy he had left; and this was attended with fatal consequences. The branches, thus mortgaged, became fixed and hereditary; so that the merchant was oppressed, whilst the king in fact received nothing. This expedient failing, a tax of three per centum was imposed, in the nature of ship-money, for the defence of the coasts and the commerce of the country, and for some years it was properly applied; but it then became a part of the ordinary revenue, and went into the king's exchequer without account. This made way for diverting other appropriated branches; as, for instance, that for the repair of fortifications, the money being strictly levied, whilst the works were suffered to decay and tumble down; and also that for the maintenance of the conquests in Africa, by which the garrisons mouldered away, and the places were lost. Upon the whole, in the space of eighteen years, the nation was visibly impoverished; and yet the government of Philip was so incomparably preferable to that of his immediate successors, that his death was justly regretted, and the Portuguese were taught by experience to confess, that of bad masters he was the best.

Philip III. and Philip IV. His son Philip, the second of Portugal and the third of Spain, sat twenty years upon the throne before he paid a visit to Portugal, where the people put themselves to a most enormous expense to receive him. He held an assembly of the states, in which his son was sworn as his successor. Having done all that he wanted for himself, he acquired a false idea of the riches of the nation, from the immoderate and foolish display made during his stay at Lisbon; and having shown himself little, and done less, he returned into Spain, where he acted the part of a good king upon his death-bed, in deploring bitterly that he had never thought of acting it before. The reigns of Philip III. and Philip IV. were characterised by a series of bad measures, and worse fortune. All their dominions suffered greatly; Portugal most of all. The loss of Ormus in the east, and of Brazil in the west, together with the shipwreck of a fleet sent to escort one of merchantmen from Goa, brought the nation incredibly low, and encouraged the Conde Duke to hope that they might be entirely crushed. These are the heads only of the transactions of forty years. To enter in any degree into particulars, would only be to point out the breaches made by the Spanish ministers in the conditions granted by Philip; which, with respect to the nation, was the original contract and unalterable constitution of Portugal whilst subject to the monarchs of Castille, but which notwithstanding, they often flagrantly violated.

The Portuguese oppressed by the Spaniards. The very basis and foundation of their privileges was, that the kingdom should remain separate and independent, and consequently that Lisbon should continue as much its capital as ever. But so little was this observed, that neither promotion nor justice was to be obtained without journeys to Madrid, which was not more the capital of Castille than it was that of Portugal. The general assembly of estates was to be held frequently, and they were only held thrice in the space of sixty years; two of them being held within the first three years. The king was to reside in this realm as often and as long as possible. Philip I., however, was there but once; Philip II. resided only four months; and Philip III. never at all. The household establishment was suppressed during all these reigns. The viceroy was to be a native of Portugal, or a prince or princess of the blood; yet when any of the royal family bore the title, the power was in reality in the hands of a Spaniard. Thus, when the Princess of Mantua was vice-queen, the Marquis de la Puebla was sent to assist her in council, and she could do nothing without his advice. The council of Portugal, which was to be composed entirely of natives, was filled with Castillians, as the garrisons also were, though the contrary had been provided. The presidents of provinces, or corregidors, were to be natives; but, by keeping those offices in his own hands, the king eluded this article. No city, town, or district, was to be given to any except Portuguese; yet the Duke of Lerma had Beja, Serpa, and other parts of the demesnes of the crown, which were formerly appendages of the princes of the blood. None but natives were capable of offices in the courts of justice, in the revenue, in the fleet, or of holding any post civil or military; yet these were given promiscuously to foreigners, or sold to the highest bidder, not excepting the government of castles, cities, and provinces. The natives were so far from having an equal chance in such cases, that no situations in the presidios were ever given to them, and scarcely any in garrisons; and whenever it occurred, in the case of a person of extraordinary merit, whose pretensions could not be rejected, he was either removed, or not allowed to exercise his charge, as happened to the Marquis of Marialva and others. The forms of proceeding, the jurisdiction, the ministers, the secretaries, were all changed in the council of Portugal, being reduced from five to three, then two, and at last to a single person.

A revolution in favour of the Duke of Braganza. By reason of these and many other grievances too tedious to be enumerated, the detestation of the Spanish government became universal; and in 1640 a revolution took place, in which John duke of Braganza was declared king, by the title of John IV. This revolution, as being determined by the almost unanimous voice of the nation, was attended with very little effusion of blood; neither were all the efforts of the king of Spain able to regain his authority. Several attempts, indeed, were made for this purpose. The first battle was fought in the year 1644, between a Portuguese army of six thousand foot and eleven hundred horse, and a Spanish army of nearly the same number. The latter were entirely defeated; and this contributed greatly to establish the affairs of Portugal on a firm basis. The king carried on a defensive war during the remainder of his life; and after his death, which happened in 1655, the war was renewed with great vigour.

Perilous state of Portugal on his death. This was what the Spaniards did not expect; for they expressed an indecent joy at his death, hoping that it would be followed by a dissolution of the government. It would not, indeed, be easy to conceive a kingdom left in more perilous circumstances than Portugal was at this time. The king, Dom Alonso Enriquez, was a child not more than thirteen years of age, reputed of unsound constitution both of body and mind; the regency was in a woman, and that woman a Castillian; the nation was involved in a war respecting the title to the crown; and the nobility, some of them secretly disaffected to the reigning family, were almost all of them embarked in feuds and contentions with each other; so that the queen scarcely knew whom to trust or how she should be obeyed. She acted, however, with great vigour and prudence. By marrying her only daughter, the Princess Catherine, to Charles II. king of Great Britain, she procured for Portugal the protection of the English fleets, with reinforcements of some thousands of horse and foot; and at last, in 1665, the war was terminated by the glorious victory of Montesclaros. This decisive action broke the power of the Spaniards, and fixed the fate of the kingdom, though not that of the king of Portugal. Alonso was a prince whose education had been neglected in his youth, who was devoted to vulgar amusements and mean company, and whom the queen for these reasons wished to deprive of the crown, that she might place it on the head of his younger brother Dom Pedro. To accomplish this object, she attempted every method of stern authority and secret artifice; but her endeavours of every kind were vain. The

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Portuguese would not consent to set aside the rights of primogeniture, and involve the kingdom in all the miseries attending a disputed succession.

Dom Alonso obliged to resign the throne.

But after the death of the queen-mother, the infant entered into cabals against the king, of a much more dangerous nature than any that she had carried on. Alonso had married the Princess of Nemours; but being impotent, and less handsome than his brother, that lady transferred her affection to Dom Pedro, to whom she lent her assistance to hurl the king from the throne. Alonso was compelled to sign a resignation of the kingdom; and his brother, after governing a few months without any legal authority, was in a meeting of the states unanimously proclaimed regent, and vested with all the powers of royalty. Soon after this revolution, for such it may be called, the marriage of the king and queen was declared null by the chapter of Lisbon; and the regent, by a pontifical dispensation, and with the consent of the states, immediately espoused the lady who had been the wife of his brother. He governed, under the appellation of regent, fifteen years, when, upon the death of the king, he mounted the throne by the title of Dom Pedro II.; and after a long reign, during which he conducted the affairs of the kingdom with great prudence and vigour, he died on the 9th of December 1706.

Dom John V.

Dom John V. succeeded his father; and though he was then little more than seventeen years of age, he acted with such wisdom and resolution, adhered so steadily to the grand alliance formed against France and Spain, and showed so great resources in his own mind, that though he suffered severe losses during the war, he obtained such terms of peace at Utrecht, that Portugal was in all respects a gainer by the treaty. The two crowns of Spain and Portugal were not, however, thoroughly reconciled until the year 1737; but from this period they became every day more united, which gave much satisfaction to some courts, and no umbrage to any. In this situation of things a treaty was concluded in 1750 with the court of Madrid, by which Nova Colonia, on the river Plata, was ceded to his Catholic majesty, to the great regret of the Portuguese, as well on account of the value of that settlement, as because they apprehended that their possession of the Brazils would by this cession be rendered precarious. On the last of July the same year, this monarch, worn out by infirmities, died in the sixty-first year of his age, and the forty-fourth of his reign.

Dom Joseph I.

He was succeeded by his son Joseph I., who ascended the throne of Portugal under very favourable circumstances; but his reign, although short, was marked by great national calamities. The most remarkable event which occurred was the memorable earthquake, which, in November 1755, destroyed one half of the city of Lisbon, and buried thirty thousand people under the ruins. Two hours had scarcely elapsed after this terrible convulsion, when, to aggravate its horrors, flames burst forth from different quarters of the city, and the conflagration raging with terrific violence for three days, Lisbon was completely desolated. The royal family were fortunate enough to escape; but amongst the victims were the Spanish ambassador, and many other persons of distinction. Britain promptly afforded relief to the sufferers; an act of generosity the more honourable to her, as she had every reason to be dissatisfied with the conduct of the king of Portugal. From the commencement of his reign, he had thrown great obstructions in the way of our commerce, evading treaties, and imposing vexatious imposts; and it seemed perfectly clear, that his object was to annihilate the commercial intercourse which had for so many ages subsisted between the two countries. The same spirit of humanity was evinced by Spain; but both nations received an unworthy return, although Britain had most to complain of. The Spaniards were only treated with silent ingratitude, but the English were detested as heretics.

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Scarcely had the agitation which these great calamities gave rise to subsided, when Portugal was again thrown into commotion by a pretended conspiracy against the life of the king. No light has yet been thrown upon this dark transaction. The leading parties involved in it, and the ultimate object which they aimed at, are alike unknown. Suspicion fell on various classes of persons, particularly on certain ecclesiastics, who were said to have been incensed at the reform introduced by Dom Joseph; on the creatures of Spain, who aspired to the reunion of the two kingdoms under one sceptre; on the Jesuits, who were represented as indignant at the restriction of their ancient privileges; and on a prince of the royal family. All that is known with certainty is, that the scaffold flowed with noble blood; and that the Jesuits, against whom Pombal had artfully inflamed the passions of the multitude, were stripped of their possessions, whilst their expulsion was decreed by the crown. In fact, the members of the company of Jesus were supposed to be at the bottom of every calamity; whether it was a dispensation of Providence, or an act of human depravity. Even the earthquake was boldly ascribed to them. Pombal had sworn their destruction, and the gross ignorance of the people ministered to his vengeance. Another occurrence of this reign was a rupture with the see of Rome, every servant of the pope being expelled from Portugal, and all intercourse between the two courts suspended for about two years. A more important event was the invasion of the country by Spain. This aggression originated in the refusal of the king to join the alliance of France and Spain against England. War was immediately declared against him, and troops marched to the frontiers of his kingdom. The ally whom he had so long neglected, and even deliberately ill used, was appealed to, and not in vain. Troops, arms, and all necessary munitions of war, arrived from Britain; and although the invaders succeeded in capturing Miranda, Braganza, and Almeida, their triumphs were speedily put a stop to by the combined forces of Britain and Portugal. At the instance of the British cabinet, the Count de Lippe was brought from Germany to assume the command of the whole army. This commander was ably assisted in his operations by General Burgoyne, and they had soon the glory of freeing the country from the Spanish army. The consequence of this triumph was a peace, solicited and obtained by the two hostile courts, now hopless of success, and in apprehension of fresh disasters.

The remainder of this king's reign, extending from the year 1763 to 1777, was occupied by the introduction of measures for social, agricultural, and commercial improvement. He laboured to improve the police and judicial administration, and not without success. He founded schools in the large towns, and improved the system of study in the university of Coimbra. He encouraged agriculture, the fisheries, and trade with the colonies; but in attempting to give a stimulus to home manufactures, by laying such duties on articles of British produce as amounted to an almost total exclusion of them from the Portuguese market, he acted with equal short-sightedness and ingratitude. One monument to his honour, more noble than the statue of bronze which his grateful subjects erected to him in Lisbon during his life-time, remains to be mentioned. This was a decree by which the grandsons of slaves, and all who should be born after the date thereof, were declared free. Although this benefit was confined to Portugal alone, yet, considering the state of matters at the time it was conferred, it must be regarded as an amazing stride in the career of improvement. Joseph I. died in 1777, and was mourned by his people as the best monarch who had swayed the sceptre of Portugal since the days of Philip I. It must, however, be added, that the administration of Pombal threw a false splendour on the reign of this monarch. In principle a freethinker, in profession a reformer, and in character a cruel and cold-blooded

History. tyrant, this man was lauded to the skies by the infidel philosophers of France, because he had expelled the Jesuits from Portugal with every circumstance of barbarity and iniquity. But few or none of his pretended reforms survived his fall, which was hailed with satisfaction by the whole nation; and his name is now remembered only in connection with some of the darkest and foulest deeds recorded in the historical annals of Portugal.

Maria. Joseph was succeeded by his daughter Maria, whom the necessities of state had induced her father to give in marriage to his own brother. Such revolting connections are unhappily far from rare in the modern history of Portugal. Some attempts were made to exclude her in favour of a nephew, but they proved completely abortive. Though the abilities of this queen were limited, yet she was actuated by good intentions. Her administration was feeble, but upon the whole beneficial. She followed the example of her father in encouraging national industry and reforming the administration of justice. She founded the Academy of Sciences, and introduced into the convents of friars a compulsory form of education, embracing useful literature, philosophy, and the sciences. She likewise endowed several admirable charitable institutions, and went so far in judicial reform as to abolish the law of imprisonment for debt. In short, had her foreign policy resembled her domestic administration, Portugal would have had no reason to complain of her. Maria was forced into a family compact by her powerful neighbours of France and Spain, by which the influence of the latter was strengthened and confirmed, whilst in the same degree that of England was weakened. This alliance was accompanied by a treaty of limits, which fixed the boundaries of Brazil, Paraguay, and Peru, the arrangement being peculiarly favourable to Spain.

In the year 1792 the queen exhibited symptoms of mental alienation, and John Maria Joseph, prince of Brazil, was appointed regent. One of the first acts of his administration was a declaration of war against the French republic, a step which he was induced to take from his connection with England. But commercial distress, the accumulating debt of the country, and the menacing language which France compelled Spain to adopt towards her neighbour, led to a peace in 1797. In 1799 the malady of the queen appearing to be incurable, the prince was confirmed in the regency, with full regal powers; but he made no change in the policy of the government. The same year he was again encouraged to arm against French aggression, in alliance with England and Russia; the victorious career of the revolutionists having received a severe, although, as it proved, only a temporary check. But the glory of the French arms was restored by the genius of Napoleon. After this conqueror had fully confirmed his ascendency, Spain was under the necessity of declaring war against Portugal in the year 1801; but it was soon terminated by the treaty of Badajoz, in consequence of which Portugal was compelled to cede Olivenza to Spain, and likewise to pay a considerable sum of money. After this the prince enjoyed but a mere shadow of power, and at considerable sacrifices maintained a nominal independence, until at last, in 1807, a hostile army under Marshal Junot invaded Portugal; and the house of Braganza was declared by Napoleon to have forfeited the throne. This bold declaration was owing to the prince having refused to seize the English property in his dominions. Having embarked with his family for Brazil, the French general immediately afterwards took possession of his capital, and Portugal sank into the condition of an appendage of France.

General Junot issued a proclamation, in which he declared that justice should be duly administered, tranquillity preserved, and the future happiness of the people solicitously guarded. But these professions were far from satisfying a people of whom the lower classes were dying of absolute want, and two thirds of the merchants were bankrupt. A British force under the Duke of Wellington (then Sir Arthur Wellesley) was promptly despatched to Portugal, where it was joined by a considerable body of national troops, now mustered in the northern provinces, and determined to maintain the struggle for freedom. A junta was immediately established in Oporto, to conduct the government. After some sharp skirmishing between the two armies, the decisive battle of Vimiero,[1] which was fought on the 21st of August 1808, overthrew the power of France in Portugal. The convention of Cintra followed, and the country was evacuated by the French troops. The immediate consequences of this convention, which at the time was severely censured, were highly beneficial. The government displayed an energy which restored subordination, and was felt all over the kingdom. A levy *en masse* of the whole male inhabitants, from fifteen to sixty years of age, was demanded; but it does not appear that the call was responded to with much alacrity. Towards the close of the year 1808, Madrid having surrendered, and the British army under Sir John Moore having been compelled to retreat through the mountains of Galicia to Corunna, the subjugation of Portugal was again resolved upon by the French. The intelligence of the approaching invasion at first spread consternation and dismay throughout Portugal, for it was in no condition to offer any serious resistance to the force of the enemy that menaced the frontiers. But fresh reinforcements arrived from Britain, and General Beresford, who had been appointed commander-in-chief of the armies of Portugal, having established a system of subordination and discipline amongst the troops, confidence was in a great measure restored before a blow could be struck.

Marshal Soult entered the kingdom of Portugal at the head of the French army, after dispersing the Spanish force in Galicia. He was feebly opposed by the Portuguese, who, however, displayed a laudable eagerness to fight. Their commander, General Freyre, was opposed to a regular engagement; but his unruly troops rose in mutiny, and massacred both him and his supporters, under the suspicion of treachery. They were led against the enemy by Baron Eben, a German in the British service, and the battle of Carvalho da Este was fought and lost. Soult then invested Oporto, and although the city had been strongly fortified and garrisoned, it was carried by assault on the 29th of March 1809, after a feeble defence of only three days. Immediately on entering the town, the French soldiery commenced an indiscriminate slaughter of the inhabitants; and although their commander used every effort to repress their fury, the plunder and licentiousness had continued a day and a night before subordination could be restored. The defeat of the Spanish army at Medellin opened an easy road to Lisbon; but the French force was divided into three separate bodies, under three independent commanders, Soult, Victor, and Lapisse, though, from fear of being separately committed, the whole remained inactive, or only engaged in insignificant manœuvres. Each commander appears to have waited for intelligence as to the movements of the others, and by this delay the capital was saved. Such was the situation of affairs when Sir Arthur Wellesley landed at Lisbon on the 23d of April, and assumed the chief command of the armies of England and Portugal. By a series of brilliant manœuvres, the British commander compelled the French to abandon Portugal. But Napoleon being pledged to his people and the world to conquer that country, early in 1810 an army of seventy-two thousand men was assembled in the vicinity of Sala-

[1] The operations of the British army in Portugal and Spain having been already narrated at sufficient length in the article BRITAIN, no details will here be given.

History. manca, and the command of it intrusted to Marshal Massena. After clearing his way to Portugal, by the capture of several strongly-fortified places, the French general advanced upon Lisbon. But his vigilant enemy had well employed the time afforded him, by preparing a secure asylum for his troops, by which he at once kept his footing in the peninsula, and defended Lisbon against a greatly superior force. This formidable defensive position is celebrated in military annals by the name of the lines of Torres Vedras. The advance of Massena, the battle of Busaco, the stand made at Torres Vedras, the retreat of the French, and their final evacuation of Portugal, will be found described in the article BRITAIN. It is true, that in the subsequent operations of the war, some parts of the kingdom were included in the theatre of hostilities, yet they never extended much beyond the frontiers. During the remainder of the war, however, the troops of Portugal bore an active and creditable part in almost every encounter with the enemy.

John VI. On the death of Maria, John VI. ascended the throne of Portugal and Brazil. The establishment of the court of Lisbon in an American settlement, though productive of little good to the mother country, led to important results. In the first place, it induced Brazil to withdraw itself from dependence on England; and, secondly, it paved the way for that colony erecting itself into a separate state. But the influence of England in Portugal continued, and the condition of the kingdom for the present remained essentially unchanged by the transference. The peace of Paris, concluded in May 1814, which, it was believed, would place everything on a proper basis, did not realize the expectations of the nation. Spain evaded the restitution of Olivenza, which had been provided for by the congress of Vienna; whilst, at the same time, Portugal was required to restore French Guiana to France. The court of Rio therefore took possession of the Banda Oriental; but an account of these transactions has been given in another part of this work (See BRAZIL.) These circumstances rendered the condition of Portugal far from tranquil. The country felt that the order of things had been inverted, and the parent state had become a dependent on her colony. A conspiracy of a very extensive nature was timeously discovered in the army, and its progress checked; but the spirit which generated it was not extinguished. In short, everything was ripening for a fundamental change in the administration and constitution of government; and the Portuguese people were soon afforded an opportunity of showing their dislike of the absence of the court, and the predominance of English influence. The continual bickerings between the commander of the forces and the regency induced Marshal Beresford to repair to Rio de Janeiro, to obtain fresh instructions, and, it might be, fresh powers, from the king; but during his absence that revolution burst forth which completely changed the whole political aspect of the kingdom.

The first symptoms of this revolution were exhibited at Oporto on the 24th of August 1820, both the citizens and the army acting in concert. The soldiers swore fealty to the king, the cortes, and the constitution which might be adopted, and the civil authorities declared in favour of the measure. A junta of thirteen members was chosen by acclamation; and a declaration was addressed to the nation, stating, that the assembling of the cortes and the adoption of a new constitution were the only means of saving the state. On the 15th of September, the day on which it was usual to celebrate the deliverance of Portugal from France, the regency in Lisbon, fearing to assemble such a multitude of people as generally met on that day, resolved to omit the ceremony. But the troops and the citizens met, and deposed the government; declared for the king, the cortes, and the constitution; and installed a temporary council as a provisional government. Thus a complete revolution was effected, without either violence or bloodshed. The provisional government formed a union with the junta of Oporto on the 1st of October; and one of the earliest acts of this united body was to despatch Count Palmella, the head of the royal regency, to Brazil, with an account of the transactions which had just taken place, and a petition that either the king or the prince royal would return to Europe and assume the sovereignty of Portugal. In the mean while, dissensions of the most inveterate description arose amongst the members of the two juntas. One party, being eager for the immediate adoption of the constitution which had been given to Spain, compelled the supreme junta to declare for, and oblige the troops to take the oath of fealty to, that constitution. But the ascendency of this party was of short duration, and ultimately it was agreed that, for the present, no part of the Spanish constitution should be in force except that which related to the mode of electing the cortes. This was to choose one deputy for every thirty thousand inhabitants. Clergymen, lawyers, and officers, were the sorts of persons who were chiefly elected, few men of wealth or family being chosen. On the 26th of January 1821, the cortes met, and named a regency and ministry, declared the late insurrections legal and necessary, and abolished the inquisition. On the 9th of March, the articles of the new constitution were adopted almost unanimously. By these, freedom of person and property was guaranteed, and the liberty of the press, legal equality, the abolition of privileges, the admission of all citizens to all offices, and the sovereignty of the nation, were secured. One chamber and a conditional royal veto were likewise resolved upon. History.

John VI. returned from America, leaving his eldest son, Dom Pedro, viceroy or regent of Brazil; but the aged monarch found, on his arrival in Europe, greater troubles than those from which he had fled. He was under the necessity of acceding to certain restrictions on his power, imposed by the cortes, before he was permitted to disembark. On landing, he swore to observe the new constitution, and concurred in all the succeeding acts of the cortes. To add to his disquiet, Dom Pedro accepted the dignity of constitutional Emperor of Brazil, in May 1822, and a complete separation took place between the two countries. The constitution of Portugal was finally completed and sworn to by the king on the 1st of October 1822; and, shortly afterwards, the session of this extraordinary cortes closed. The members of the old cortes occupied several months in reorganizing the different departments of the administration; but measures were rapidly maturing for the total overthrow of the new order of things. After several sanguinary engagements, the insurgents were driven from the northern provinces into Spain, and a Portuguese regency was established at Valladolid in May 1823. At the head of the plot for abolishing the new constitution was the queen, a Spanish Infanta; and several of the nobility and clergy were likewise engaged in it. Everything was now ripe for execution. Dom Miguel violated the promise which he had solemnly given to his father, by becoming the leader of the counter-revolutionists, and inviting the nation to rise under the royal standard against the anarchical policy of the cortes. The greater part of the troops declared for the Infant, and John VI., yielding to the force of circumstances, named a new ministry, and declared the constitution of 1822 null and void. Sixty members of the cortes protested against this proceeding; but the king, a mere puppet in the hands of his son, was borne along by the force of the current, without being able to give any effectual check to its course.

The events which subsequently occurred in Portugal are still too recent to have yet assumed their just historical proportions. The object of the queen and the Infant was to induce the king to resume absolute power; but John VI. firmly

History. declared his resolution not to comply with this request. The counter-revolutionists, however, began to act independently of his authority. The national guards and militia were disarmed, a censorship of the press was established, many of the staunchest constitutionalists were disposed of by imprisonment or expatriation, and the highest offices were conferred on the absolutists. Finally, a junta, with Palmella at its head, was organized, to draw up a constitution adapted to a representative monarchy. The queen and the Infant, with their followers, exerted their whole energies to prevent the establishment of a constitution. Palmella and his coadjutors drew up a constitutional charter. By this act he rendered himself obnoxious both to the queen and Dom Miguel, as well as to the absolutist party; and the king, probably more in compliance with their wishes than from his own conviction that the plan was bad, rejected it. The intrigues of the absolutists still continued. Dom Miguel was appointed commander-in-chief of the army, and, having obtained this office, determined at one blow to extinguish all the hopes of the constitutionalists, and to put an end to the system of moderation, according to which the king continued to act. Upon the 30th of April 1824, Miguel called the troops to arms, and issued proclamations, in which he declared it as his intention to complete the work of the 27th May 1823, and to emancipate the king from the control of free-masons and others by whom he was surrounded. The ministers and other civil officers, to the number of one hundred persons, were on the same day put under arrest; but when the king ascertained what had occurred, he declared that the whole had been done without his orders. As an excuse for his conduct, the Infant said that he had taken these steps for the purpose of frustrating a conspiracy which had been formed against the king's life. On the representations of the foreign ambassadors, the individuals imprisoned were released; and on the 3d of May the king issued a decree, commanding an immediate investigation of the pretended treason. He also pardoned the Infant for his usurpation of the royal name; but this incorrigible person still acted on his own authority, as if he were absolute sovereign, continuing to arrest obnoxious or suspected individuals. John, finding himself in danger of falling a victim to the intrigues of his son, contrived to escape on board of an English vessel which lay in the Tagus. He deprived the Infant of his command, and summoned him into his presence. The prince obeyed, and having confessed his various delinquencies, received the royal pardon, with permission to travel. The king returned on shore, proclaimed an act of amnesty in favour of the adherents of the cortes of 1820, and, reviving the old constitution of the estates, summoned the cortes of Lamego. A new junta was appointed to prepare a constitution; but the convocation of the old cortes was resisted, and conspiracies were formed against the king and his ministers. The latter were themselves far from being unanimous, chiefly in regard to Brazil, so that a new ministry was appointed in January 1825. Portugal and Brazil assumed a hostile attitude, but at length John VI. concluded a treaty with the emperor Dom Pedro I. of Brazil, in which he acknowledged the entire independence of that country, and resigned the sovereignty of it to his son, reserving for himself only the title of emperor. This good-natured monarch, who was incompetent to struggle with the troubles of his age, and the political degeneracy of his nation, died on the 10th of March 1826, having previously appointed his daughter Isabella regent of Portugal.

Isabella for a short time governed Portugal in the name of the emperor of Brazil, Dom Pedro, who was the legitimate successor to both the European and American possessions of the house of Braganza. On the 23d of April 1826 he granted a constitution to Portugal, which established two chambers, and in some other respects resembled the French charter. Not long afterwards, he surrendered Portugal to his daughter, Donna Maria, as an independent queen, on condition of her marrying her uncle, Dom Miguel. The prince at once agreed to this arrangement, but, with his characteristic duplicity, resolved on evading its conditions. The absolutists, of whom he was the recognised chief, were still very strong in the country; and a party was formed, the very object of which was to overthrow the constitution, and proclaim Dom Miguel absolute king of Portugal. The attempt was made, but it proved unsuccessful. A strong British army was landed at Lisbon, and the country, thus overawed, was in some measure restored to tranquillity. Spain, which had secretly fomented the insurrection, was now forced to yield. In July 1827, Dom Miguel was appointed by his brother lieutenant and regent of the kingdom. The prince immediately quitted Vienna and returned to Portugal, taking Paris and London on his way. He was much caressed whilst in England, and pledged himself to abide by the terms required by Pedro. He arrived in Lisbon on the 26th of February 1828, and immediately assumed the administration of the government, at the same time taking the oath to maintain the constitution. But oaths were in his eyes a mere formality of state, involving no moral obligation. He assumed the sceptre as absolute king; changed the ministry to make room for his tools; dissolved the chamber of deputies, which was much too liberal for his views; altered the mode of election; and, in short, restored the reign of absolutism. The recall of the British troops removed another obstacle from his path. He convoked the ancient cortes of Lamego, and was in a fair way of carrying everything before him. But the military in general were unfavourable to his projects. The garrison of Oporto declared for Dom Pedro and the charter; other bodies of troops followed their example; and a corps of six thousand men advanced towards the capital. But they were defeated by a superior force, and the efforts of the constitutionalists were for the present baffled.

The object of Dom Miguel was now to consolidate his power, and get himself proclaimed king. The cortes met, and all who were likely to oppose him having been carefully consigned to dungeons, or driven into exile, this body unanimously declared Dom Miguel lawful king of Portugal and the two Algarves. The pretext by which the cortes endeavoured to vindicate its conduct was, that as Dom Pedro had become a foreigner, he had neither a right to succeed himself, nor to appoint a successor. On the 4th of July 1828, Dom Miguel confirmed the decree of the cortes, and assumed the title, as he had already done the powers, of royalty. The punishment of those implicated in the Oporto insurrection followed as a matter of course. An expedition was likewise sent against the refractory islands, which had refused to acknowledge the usurper; and Madeira and the Azores were, with one exception, reduced. The whole dominions of Portugal now became a scene of terror, distrust, and misery, under the sway of this hypocritical and merciless usurper.

In the meanwhile, Donna Maria had set sail from Brazil for Europe; but on arriving before Gibraltar, she found that, under actual circumstances, it would be injudicious, if not dangerous, to land at Lisbon, and accordingly steered for the English shores. She remained some time in London, and during her stay was entertained as queen of Portugal. In August 1829 she returned to Brazil, in which a revolution suddenly deprived her father of his American empire. Having abdicated a crown which he could no longer retain, in favour of his infant son, the ex-emperor sailed for Europe with his daughter, to assert her claims to the throne of Portugal. Under the title of Duke of Braganza he was hospitably received in England, and instantly set to work in making arrangements for effecting the dethronement of Dom Miguel. The usurper still pursued the same course of oppression, and, not content with confining and despoiling

History. his own countrymen, he extended his outrages to British and French subjects. In the year 1830 it was calculated that forty thousand individuals were under arrest for political causes alone; and that five thousand persons were concealed in hiding-places in different parts of the country. How many had been devoted to destruction by being sent to the fatal shores of Africa, and how many had voluntarily exiled themselves, it is impossible to estimate. The British government demanded redress for the acts of violence committed against its subjects; and, on this being refused, a British fleet entered the Tagus, and terrified the tyrant into compliance. France acted in a similar manner, and with even more success; demanding an indemnity for the expenses incurred by the expedition. Even the United States despatched a fleet to Lisbon to obtain satisfaction for injuries done to American commerce. But these repeated humiliations wrought no change in the policy of Dom Miguel. The petty insurrections which frequently broke out were speedily suppressed by the vigour of the government, or the want of concert in the insurgents; and hence these ebullitions of popular indignation caused him little uneasiness. But his finances were now falling into inextricable confusion. The revenue scarcely sufficing for the household expenses and the maintenance of the troops, the usurper was driven to all manner of expedients to relieve his necessities. The island of Terceira, one of the Azores, resisted his claims; and here a regency was formally installed, with the Marquis of Palmella at its head. From this spot Dom Pedro issued a decree in favour of his daughter Donna Maria, at the same time representing Dom Miguel in his true character, as a rebel and perjured usurper.

Although neither the government of France nor that of England gave open assistance to Dom Pedro, both abstained from opposing any obstacles to his measures of recruiting. Many officers of each nation enlisted in his ranks; and towards the end of December three hundred half-pay officers and volunteers sailed for Belleisle on the coast of France, which had been fixed upon as the place of rendezvous. The intelligence of these preparations, whilst it gave encouragement to the constitutionalists, was productive of great alarm to Dom Miguel, who soon discovered that a considerable portion of his own army was not to be trusted. Lisbon became the scene of anarchy, violence, and bloodshed. A regiment of the line broke out into open mutiny, and, dividing itself into three bodies, marched upon three different points, where other troops were stationed, expecting to be joined by them. But they were sadly disappointed in this expectation. Several bloody conflicts took place, and the insurrection was ultimately suppressed. Many persons were shot for treason, and every dungeon and fortress in the kingdom was filled with suspected persons. Meanwhile the island of St Michael's was captured by a force from Terceira, under Villa Flor, one of the members of the regency. Afraid that Madeira would be the next object of attack, Dom Miguel sent a small armament for its defence; indeed a large one could not well be spared at a time when the preparations of Dom Pedro threatened to bring the contest nearer home. This prince had prosecuted his measures with great activity and perseverance; nevertheless, his means appeared altogether inadequate for the conquest of a kingdom. His levies consisted of a motley group of raw recruits, men of desperate fortunes or suspicious characters, idle persons whose object was plunder, disbanded troops from Brazil, Portuguese refugees, and the regiments which had so successfully maintained the cause of the young queen in the Azores. But a kingdom was at stake, and Pedro resolved to hazard a descent upon Portugal. The expedition sailed from the island of St Michael on the 27th of June 1832. It consisted of two frigates, three corvettes, three armed brigs, and four schooners, besides transports, and a number of gunboats to cover the landing. An officer who held a commission in the British army undertook the command of the naval department. He had been deprived of his rank as a British officer, but became a Portuguese admiral. The whole army on board did not amount to ten thousand men, scantily provided with artillery, and still more scantily with cavalry. History.

Dom Miguel made every preparation in his power to repulse the threatened attack. On the 8th of July Dom Pedro appeared before Oporto, landed his troops, and took possession of the town, without the loss of a single man. The advantages likely to result from the capture of the second city in the kingdom need not be pointed out, nor was Dom Miguel ignorant of them. He acted with decision, and immediately menaced Oporto from two points. On the 22d of July an action took place, in which his troops were repulsed, and compelled to fall back; but, on the other hand, Dom Pedro was not in a condition to follow up the victory. Another attempt in a different quarter was with more difficulty repelled; but the most discouraging circumstance for the invaders was the utter disappointment of the hopes they had entertained that the population of the country would rise in their favour, and that the army of Dom Miguel would desert its master.

The operations of the naval squadron were attended with little success. Several partial engagements took place between the fleet of Dom Miguel and that of the young queen under Sartorius; but no advantage was gained on either side. Dom Pedro had continued to fortify Oporto from the period of his landing; whilst Miguel, with equal industry, was increasing his army, the greater part of which lay on the north side of the Douro. On the 8th of September the Miguelites made an attack upon Villa Nova, the suburb of Oporto, which they carried; and the possession of this place enabled them to harass the city with a constant fire both of musketry and artillery. An attempt to recover this position utterly failed; but a convent which formed part of it still held out against all the efforts of the Miguelites. The city began to be seriously injured by the incessant fire which was kept up from Villa Nova, and all attempts to dislodge the Miguelites from their position proved abortive. On the 29th of September Dom Miguel made a general assault upon the works with which Oporto was surrounded; but, after manfully maintaining the contest for seven hours, he was compelled to retreat to his former positions. The commanders of Dom Miguel now changed their tactics. Finding that it was impossible to carry Oporto by storm, they determined to prevent all supplies from reaching the city, by erecting batteries on the Douro, so as to command the bar and channel, and thus prevent all vessels from approaching. They effected their purpose, and Dom Pedro found himself reduced to the greatest difficulties.

The operations of 1833, like those of the preceding year, consisted in partial bombardments across the river, or engagements of detachments, occasionally varied by more regular attacks and sallies to destroy works already erected, or prevent new ones from being raised. The casualties were not great on either side, nor was any permanent change effected in the relative situation of the armies. Dom Pedro began the year by placing at the head of his troops the French general Solignac, whom he had created a marshal. A few months afterwards he had a quarrel with his admiral, Sartorius, which for a time threatened serious consequences; but the naval commander being ultimately removed, his place was supplied by another British officer, Captain, now made Admiral Napier. In a short time the latter inflicted a severe blow on Dom Miguel, by the capture of several of his largest vessels, in as gallant a style as any thing recorded in naval history. In short, the fleet of the usurper was utterly annihilated, and he had now only the land force to look to. Previously to this achievement, a body of queen's troops

History. had landed at another point of the coast, and in a few days the whole of the Algarves declared for Donna Maria. This small army, under the command of Villa Flor, now Duke of Terceira, marched upon Lisbon, and on the way completely routed a greatly superior force. The capital was deserted by the garrison; the inhabitants rose *en masse*, and declared Donna Maria their lawful sovereign; and the Duke of Terceira entering Lisbon in triumph, hoisted the queen's colours on the citadel. Dom Pedro instantly set sail from Oporto to assume the government, and no sooner had the intelligence reached France and England, than both immediately acknowledged Donna Maria as queen of Portugal.

Great preparations were made for the defence of Lisbon against the Miguelite army, 18,000 strong, which, under Marshal Bourmont, an experienced general, was now advancing towards the capital. Several attacks were made on the defences during the rest of the year 1833, but the results were unimportant. The liberation of Lisbon led to the recovery of the Cape de Verd Islands, and immediately afterwards Bonavista proclaimed the queen and the constitutional charter. The political measures of Dom Pedro, after assuming the government at Lisbon, were not looked on with a favourable eye. He confiscated the property of all who had served under Dom Miguel, and was guilty of some other arbitrary acts, which did not tend to strengthen his cause.

The affairs of Dom Miguel now began to wear a very unpromising appearance. His authority, indeed, was recognised over a large tract of country; but his navy, which secured him reinforcements from abroad, was destroyed, and events had taken place in Spain which prevented the government of that country from affording him any assistance. The first military operation of importance which took place in 1834 was the capture of Leiria, an important town between Lisbon and Coimbra, which capitulated to the queen's troops on the 18th of February. A battle was lost by the Miguelites near Almoster, where Saldanha was posted; and towns and provinces began to declare for the queen so rapidly, that the cause of the usurper became desperate. He shut himself up at Santarem with a view of keeping up his communications with the frontiers of Spain, whence he expected aid. But from this very point destruction awaited him. It was a singular coincidence, that in Spain as well as in Portugal, an infant queen was supporting her cause by favouring popular privileges, with an uncle for her rival, as a representative of more despotic principles of government. The cause of the two queens being so far the same, a community of interest led to an alliance, to which the courts of Britain and France became parties. Each was recognised as lawful successor to the throne to which she aspired, and they both agreed to employ their arms jointly against their two rivals. Don Carlos was compelled to fly from Spain into Portugal, and thither he was pursued by a Spanish army, which proved even more fatal to Dom Miguel than to Don Carlos. The Miguelites, seeing all hope lost, rapidly disbanded, and only the miserable remnant of an army remained attached to the usurper. A suspension of arms was agreed to; and on the 26th of May a convention was entered into, by which Miguel formally consented to abandon the country. The terms granted him were, that he should never again set foot either in Portugal or Spain, nor in any way concur in disturbing these kingdoms; that he should leave the country within fifteen days; that he should have a pension of about L.15,000, and be permitted to dispose of his personal property, after restoring the crown jewels and other articles; and, finally, that, by his command, the troops still adhering to his cause should instantly lay down their arms, and the fortresses surrender to the queen. On the 2d of June he embarked for Genoa, where he had no sooner arrived than he issued a declaration, declaring that he had acted under compulsion in relinquishing the throne, and that the transaction was null and void. History.

The civil war being thus terminated, and the authority of the queen acknowledged all over the kingdom, an extraordinary cortes was assembled on the 14th of August. Without the intervention of this assembly, however, the government had previously adopted legislative measures of great moment. It had declared free trade with all countries; fixed the duties on all foreign imports at fifteen per cent. *ad valorem;* reduced all religious houses and regular orders of monks, incorporating their estates with the national domains; changed the state of the currency, and abolished paper money; and made various other sweeping alterations. The measures were well meant, but they were harsh and despotic notwithstanding. After the meeting of cortes, one of the first proceedings of the legislature was to consider how the executive power should be exercised during the minority of the queen. The regency was ultimately conferred on Dom Pedro, but he did not long enjoy it. He expired on the 22d of September 1834, having, during the latter years of his life, acted a part which the earlier stages of his career gave the world little reason to expect. Previously to this, the queen had set about the formation of a new ministry, in which she united some of the more moderate constitutionalists with the former ministers. Her marriage with the Duke of Leuchtenberg, the son of Eugene Beauharnois, and the brother of Dom Pedro's wife, was soon afterwards resolved upon. A bill to exclude Dom Miguel and his descendants from the throne of Portugal was passed without one dissentient voice. The budget for the year 1834 showed a considerable deficit, and this formed an excuse for treating the British auxiliaries, to whom they owed so much, with the most shameful and disgusting ingratitude.

During the year 1835, Portugal presented a peaceful and even prosperous picture, darkened a little by the intrigues of political parties. The principal object of the cortes was to reduce the public debt, or to convert it into securities which should bear a lower rate of interest than that then paid. The fund which was principally looked to for accomplishing this object was the national property, and measures were adopted for effecting sales thereof. The budget for the year ending 30th June 1836 stated the expected receipts at 8,420,257,408 milreis, and the expenditure at 12,744,161,266, being a revenue of about L.2,200,000, and an expenditure of more than L.3,000,000. No new taxes were, however, imposed to cover the deficit, because it was expected that the expenditure would decrease, whilst the receipts would remain stationary or rise.

Prince Augustus of Leuchtenberg, the husband of the young queen, having arrived in Portugal in the beginning of the year 1835, was appointed commander-in-chief of the Portuguese army, a nomination which gave rise to much contention. But death soon cut short the discussion, for the young prince expired on the 28th of March. The chambers, however, did not allow the queen to indulge long in the sorrows of widowhood. The constitutional system depended greatly on a direct succession to the throne, and before the end of the year the queen's second marriage was arranged. The bridegroom was selected from the house of Saxe-Cobourg (a great nursery for the supply of such wants), and he had the honour to be a nephew of the king of the Belgians.

On the 8th of April 1836, Prince Ferdinand of Saxe-Cobourg arrived at Lisbon, and on the following day was formally united to his royal spouse. Government now became extremely annoyed by the question, whether the king should be appointed to the command of the army, when it turned out that this was one of the special conditions of the marriage treaty. The proceeding proved very unpopular, not only with politicians, but the country, and materially

History. hastened a revolution, in which the ministry and the constitution were shipwrecked together. It does not appear, however, that the government anticipated any serious changes, as the country exhibited no dangerous symptoms of discontent, although a good deal irritated by the appointment which the queen had made. Yet the revolutionary plot must have been arranged beforehand, for even the troops of the line were seduced. On the night of the 9th of September 1836, the drums of the national guards beat to arms, and they were soon joined by the garrisons and many influential civilians. An address to the queen was drawn up, requesting her majesty forthwith to dismiss the ministry, to annul the charter, and to proclaim the constitution of 1820. The queen at first hesitated to yield to force, and to recognise statements as to the alleged jeopardy to which the nation was exposed; but she was ultimately compelled to give way. The political constitution of the 23d of September 1822 was declared to be in vigour: but it was at the same time agreed that it should undergo such modifications as circumstances had rendered necessary. A new ministry was immediately appointed, and Prince Ferdinand was deprived of his military commission. But neither the great body of the people nor the more influential classes showed any indications of accordance with the remodellers of government. Almost all the nobility, the superior clergy, and an immense number of persons holding official situations of greater or of less importance, refused peremptorily to take the oaths to the new constitution. The peers, whose existence as a separate legislative assembly was thus abolished, protested to the queen against the measure, and called for vengeance on those who had compelled her majesty to declare it in force. But this only served to irritate the revolutionists. Not long afterwards a counter-revolution was attempted. Commenced without any well-concerted plan, it was prosecuted without energy, and the results were altogether unimportant. At last negotiations being entered into between the queen and the rebels, it was proposed by the court, first, that the general cortes should be immediately convoked, but that the members should be furnished with special powers to make such alterations in the charter of 1820 as were deemed necessary to secure the liberties of the nation and the prerogatives of the crown; and, secondly, that the Chamber of Peers, as it was instituted before the revolution of the 10th of September, should vote upon these alterations, with the exception of those which might relate to the organization of the chambers. To the latter proposition the rebels refused their assent. They likewise demanded of the queen to dismiss her ministers, and form a new cabinet; and she was under the necessity of complying with their demands. Her majesty, indeed, became partially a prisoner in the hands of the democrats, and many of the most distinguished persons of her court sought refuge in voluntary exile.

The principal events which followed these changes were, the economising of the expenditure, the imposition of a tax for the support of the priesthood, the introduction of a uniform system of duties on vessels sailing from Portuguese harbours, the abolition of the slave-trade, and other measures of more or less moment, which had for their object the pacification of the country and the promotion of the general welfare. During the years 1837 and 1838, some provinces of Portugal were kept in constant terror, and, to a certain extent, ravaged by rebel banditti, whose ostensible object was to excite a rising in favour of Dom Miguel. The most noted of these guerilla chiefs was Remechido, who contrived to muster a formidable gang, and, by his daring exploits, to spread dismay throughout Algarve, the scene of his depredations. A military force was at length sent against him, by which the rebels were completely routed on the 28th of July 1838, and their leader, being taken prisoner, unceremoniously shot.

STATISTICS.

Statistics.

Boundaries and extent. Portugal, the most westerly kingdom of Europe, lies between 36° 55′ and 42° 13′ of north latitude, and between 6° 15′ and 8° 55′ of longitude west from Greenwich. According to the geographer Ebeling, its length from north to south is 301 geographical miles, and its breadth from east to west is 128 miles. It is bounded on the north and east by the Spanish provinces of Galicia, Valladolid, Salamanca, Estremadura, and Seville, and on the south and west by the Atlantic Ocean. It has the figure of a parallelogram, with its longest side from north to south.

Coast. Portugal has a coast-line of nearly five hundred miles in length, the only province not washed by the ocean being Tras-os-Montes, and Alemtejo is less so than the remaining four. On the north the coast is low at first, but it afterwards becomes rugged and steep. In Beira it again gets flat, sandy, and marshy; in Estremadura it is in one part steep, and in another almost a dead level, and very insecure; in Alemtejo it is low, being full of rocks and shallows; and although at Cape St Vincent it is high and rocky, as we proceed towards the Spanish frontier the country sinks into low sandy downs. The promontories most worthy of notice are, Mondego in Beira; Carvoeiro de Rocha and Espichel in Estremadura; and San Vincente, Carvoeiro, and Santa Maria, in Algarve. On the low coasts there are inlets of the sea, which afford opportunities for the formation of a number of excellent harbours.

Mountains. Portugal is only separated from Spain politically, not by natural boundaries or peculiarities. Hence, in all its physical relations it is to be considered as a westerly continuation of that country. The principal chains of mountains are prolongations of those which traverse Spain. In the north, between the Minho and Douro, the country is intersected in various directions by the southerly and westerly procession of the Galician and Asturian mountain ranges, which terminate at the sea in a steep and broken coast. The provinces situated in this quarter are alternating mountain and high table-land, a continuation of the lofty table-land of Old Castille and Leon. The Serra de Montezinho, near the northern frontier, is a very lofty range, on the summits of which snow not unfrequently remains during the whole year. The lofty peak of Gaviarra, however, which forms part of the Serra de Suazo, is crowned with perpetual snow. This range runs parallel with the river Lima to the sea, where it terminates under the name of the Serra de Estrica. On the left bank of the Lima extends the Serra de Gerez, in the province of Entre Minho e Douro, and, passing into Tras-os-Montes, declines towards the Lower Douro, where it bears the name of the Serra de San Catarina. In this last-named province is the Serra de Amarao, on the left bank of the Tamega, and stretching down almost to the Douro. To the east of it is the plateau of Guarda, between two and three thousand feet in height, and which on the north-east is bounded by the Serra de Montezinho. In the province of Beira extends the Serra de Estrella, a continuation of a chain which traverses Leon and Castille. This mountain ridge consists of granite and layers of sandstone. It presents a shattered and savage aspect, is covered with snow during the greater portion of the year, and in its ramifications encloses the river Mondego. Its highest summits are those of Cantaro Delgado and the Malao da Serra. Northwards it declines gently towards the Vouga, and stretches in a westerly direction to the gates of Coimbra under the name of the Serra de Alcoba. The southerly branch runs through the province of Estremadura, to the mouth of the Tagus, forming the granite mountains of Cintra, which terminate in the sea at the Cabo de Roca. To the south of the mouth of the Tagus stretches the Serra de Arabida, an inferior range. Between the Tagus and the Guadiana the country is elevat-

Statistics. ed, but, gradually sinking towards the Spanish province of Estremadura, is bounded on the south by a continuation of the Sierra Morena of Spain, which mountain chain is here penetrated by the river Guadiana. The Serra de Caldeirao, which afterwards bears the name of the Serra de Monchique, a ramification of the gigantic Morena, extends in a westerly direction to the sea, where it terminates in Cape St Vincent, and completely encloses Algarve. This serra only yields in height to that of Estrella, and to those of Suazo and Montezinho. Its loftiest peaks are Foya and Picota.

Portugal is therefore a mountainous country throughout, but its profusion of hills and mountains embosom innumerable beautiful and highly-cultivated valleys, and form several fine tracts of table-land. There are, however, two plains of some extent; one to the south of the Tagus, of which that of Santarem forms a continuation, and one on the mouth of the Vouga.

Rivers. Portugal receives its principal rivers from Spain. The largest are the Tagus, the Guadiana, the Douro, the Lima, and the Minho. The Tagus originates in the Sierra d'Albaracin, on the borders of Cuença and Aragon, flows at first in a northerly direction, and then turns to the south, but during the most part of its course its general bearing is westerly. After traversing several Spanish provinces, it enters the Portuguese territory near the point where it receives the Sever, separates the provinces of Beira and Alemtejo, and after dividing Portuguese Estremadura into two unequal parts, falls into the Atlantic. It receives the waters collected between two parallel ranges of mountains, flows through a mountainous country, and its current is much broken by rocks and cataracts. Its waters are turbid, and annually overflow and fertilize the extensive plains in the environs of Santarem and Villa Franca. Lower down it forms many marshes of considerable extent, which yield a large revenue. The length of its course is four hundred and fifty miles. It is affected by the tide a considerable distance above Lisbon, but is only navigable to Abrantes. Its width is so great near its mouth as to make it resemble a vast lake or arm of the sea; and at Lisbon it forms one of the finest and safest harbours in the world. The tributaries which it receives on the north are the Elga, the Ponsal, and the Zezere; and those from the south are the Sever, the Sorraya, erroneously called Zatas in most maps, and the Canha; but none of these are navigable. The rivers worthy of notice which have their source in Portugal are the Cavado, Ave, Vouga, Mondego, Saado, Odemira, Portimao, and Rio Quarteira. The Cavado rises in the Serra de Gerez, and after traversing the province of Minho, discharges itself near Esposenda, being only navigable for seven miles. The Vouga has its source in Beira, and after traversing this province, enters the ocean below Aveira. The Mondego issues in the Estrella, crosses Beira and the plains of Coimbra, and finally joins the ocean near Figueira and Buareos. This is the largest of the rivers belonging exclusively to Portugal, and it is navigable for sixty miles, except in summer, when its waters considerably diminish. Its sands occasionally yield particles of gold. The Saado or Sadao has its source in Alemtejo in the Serra de Monchique, and flows with a north-westerly course towards Estremadura. It becomes navigable from Porto de Rey, and enters the ocean by a large bay to the south of Setubal. The same Serra gives rise to the Odemeira and Portimao, the former being navigable to the town of the same name, and the latter as far up as Silves. The Rio Quarteira has its source in the Serra de Caldeirao, and forms at its mouth the small port which bears its name. These rivers, when swollen by the winter rains, overflow their banks, much to the advantage of the country, for the waters leave a rich deposit behind them. In summer they are very low, and many of the smaller rivers of Portugal are dried up during that season. They are in general much obstructed by rocks and bars of sand at their mouths, by which navigation is greatly impeded. Statistics.

Lakes and springs. Portugal possesses no navigable canals worthy of notice. On the coast, especially in Alemtejo and Beira, there are morasses, lakes, and inferior inland seas, none of them being of great circumference. Several mountain lakes on the Serra de Estrella are tepid, throwing up bubbles, without, however, materially troubling the waters, which are of crystal clearness. Portugal is rich in medicinal springs, some of which are used for baths. They consist of gaseous and saline mineral waters, and of sulphureous and chalybeate springs. The most celebrated sulphur and warm baths are the Caldas de Gerez in Minho, the Rainha and the Oeiras in Estremadura, those of Chaves and Anciaes in Tras-os-Montes, of San Pedro do Sul and Penagarcia in Beira, and of Monchique in Algarve. The best chalybeates are at Torro de Moncorvo in Tras-os-Montes, those of Amaranha and Guimaraens in Minho, and of Villas in Estremadura.

Geology and mines. Granite composes the highest mountains of Portugal. The entire province of Minho, and the northern portion of Tras-os-Montes, are formed of it; and, besides, it is found in many other parts of the kingdom. Schistus rock, lying over the granite, also covers a large portion of the country. It forms the frontier mountains of Algarve, those of moderate height in Alemtejo, those of Beira in the environs of Castello Branco, and the chain which accompanies the course of the Douro. The primitive calcareous formation forms a continuation of the mountains between Lisbon and Coimbra, as the Serra de Lousaa, Porto de Moz, and Monte Junto, with the Serra de Arrabida, and the mountain chain which reaches to Algarve. Coal is met with in this formation near Buareos, mineral coal at Cape Espichel, and sandstone is sometimes found covering it. The rocks near Lisbon and at Cape St Vincent are of the tertiary formation, more or less mingled with trap. When the granitic rocks blend with schistus, it is by layers; and it is connected with the latter by a stratification, resembling micaceous schistus. The calcareous structure is changed in Tras-os-Montes into a true micaceous schistus; and it is only here that mountains of the latter are seen in a pure state.

Tin mines appear to have been wrought by the Carthaginians in this part of the peninsula; and it is affirmed that mines of tin-stone existed in some granitic mountains of Beira. Mines of gold and silver were wrought in this country by the Romans. During the last century lead ores were worked near Mogadouro, in Tras-os-Montes, and in the vicinity of Longroiva, on the banks of the Rio Prisco. In Tras-os-Montes a silver-mine was wrought in the year 1628. Mines of plumbago occur near Mogadouro, and iron-mines in the same country, near Figueira and Torre de Moncorvo. The iron forge of Chapacunha is supplied from them. In Estremadura there are two very old establishments of the same kind, one in the district of Thomar, and the other in that of Figuero dos Vinhos. On the frontier of that province, and of its neighbour Beira, are situated the mines of red oxyde of iron by which they are supplied. Iron indeed is one of the most abundant minerals in the country. The mountains in the neighbourhood of Oporto everywhere give indications of copper and other ores; and at Couna there is a deposit of cinnabar. In Portugal there are also mines of antimony, bismuth, and arsenic. Some of the rivers of this country, as well as those of Spain, are washed for the gold which they contain; and it is said that in this way large quantities of the precious metal were formerly collected. The river Tagus was anciently celebrated for the particles of gold which were found mingled with its sands; but its greatest riches are now borne on its bosom. Indeed, none of the streams yields a quantity worth much above the labour of collecting it. There is only one

Statistics. gold-mine in Portugal, situated in a place called Adissa, in the district of St Ubes; but its annual produce is a mere trifle, not reaching twenty pounds weight at an average. Two coal-mines exist; one near Figueira, and the other near Oporto. The country abounds with most beautiful marbles, but they are comparatively little wrought, from the expenses required to bring them to market. Precious stones are found in Portugal, and also quarries of limestone, gypsum, slate, freestone, millstone, black agate, together with immense beds of pyrites and marcasites, potters' and porcelain clay, and pits of common salt.

Climate and soil. Various causes conspire to produce great differences in the climate of Portugal in different situations. The most obvious one is the inequality of the soil; but vicinity to the ocean, and to mountain ranges, which afford shelter from the winds, or expose to the direct influence of the sun, also greatly affect the temperature. The mountain chains in the northern part of the country are very rugged and cold, the limits of perpetual snow being in this latitude under eight thousand feet. This cold region comprises a considerable portion of the provinces of Tras-os-Montes and Beira, and the whole of the northern frontiers of Minho. It is to be observed as a general rule, that the sea-coast of these provinces, as well as that of all the others, is very warm, the heat of summer, however, being tempered by the sea-breezes. The elevated plains and mountains are sterile, and destitute of wood; but the valleys and other low situations have a mild and agreeable climate, and are for the most part very fruitful. A great part of Minho is especially deserving of notice for its delightful climate. Estremadura, on the other hand, is very hot in summer and very cold in winter; but the high land throughout the whole southern portion of Portugal has an exceedingly agreeable temperature, equally removed from excessive heat in summer and severe cold in winter. Algarve alone has an African climate, but the excessive heat is greatly tempered by the sea-breezes. Some striking anomalies occur, such as intense summer heats in elevated situations; but they are to be accounted for from the position and nature of the mountain ranges which environ them, and their distance from the ocean. The warmer parts of Portugal have a short winter and a double spring. The first, which commences in February, is a delightful season. The succeeding months are variable, being in some years hot and dry, and in others cold and rainy. Harvest is gathered in June. Summer commences in the last week of July, and continues till the beginning of September. The heat is then very great, parching up all the vegetation on the plains and sea-coast, so that it is necessary to water plants to preserve them from destruction. But even during this hot season the evenings and nights are fresh and cool, and the table-lands and other elevated parts enjoy a modification of temperature. Rain begins to fall early in October, and the vegetation of spring immediately succeeds to that of autumn. Winter lasts from the end of November till February, but the cold is seldom excessive, except in very elevated situations. In December heavy rains descend, accompanied by violent whirlwinds; it is during this period that the rivers are so liable to overflow their banks. The climate of Portugal, in general, may be pronounced salubrious, particularly along the coasts and on the table-lands. Fevers of various kinds appear to be the diseases most prevalent, but there are disorders peculiar to different localities. Almost all the mountain chains of Portugal show, in extinct and shattered craters, their former volcanic activity; and in many districts, in the country around Lisbon for instance, earthquakes are not unfrequently felt in harvest and winter. The fearful convulsion which destroyed the capital has already been mentioned in the preceding historical sketch. Portugal is rarely visited by violent storms, and thunder is only heard during autumn and winter.

Statistics. Productions. From the great differences of level which Portugal presents, it abounds in every variety of vegetable productions. Forests of birch, oak, and chestnut are abundant; and fruit is everywhere plentiful. Orchards are met with at the foot of large mountain chains; and lower down may be found the cork-tree, kermes, fir, lemon, and orange. The olive is widely distributed, and the vine is cultivated to a great extent. In the warmest regions we find the aloe of America and the date of Africa. Figs, raisins, almonds, melons, water-melons, plums, cherries, peaches, apples, pears, and chestnuts, are all objects of attention. Of grains, those chiefly raised are maize, barley, wheat, and rye; rice is likewise an object of attention in some parts. Potatoes and other vegetables are partially cultivated, together with hemp, flax, and cotton. The Flora of Portugal, although abundant in some parts, presents little that is remarkable. None of the plants of France or Spain, and only a few of those of Italy and Sicily, are found. In the cold regions a few plants similar to those in the west of England are met with. In the warmer districts poppies thrive well, and the coasts of Beira and Estremadura, with the low sandy plains of Alemtejo, are adorned with the cistus and many varieties of heath. On the northern mountains is a tree peculiar to them, which is called azerino.

Agriculture. Portugal is behind almost every nation of Europe in agriculture; and the various improvements which are general elsewhere have here been slowly and but recently introduced. The soil is neither manured nor tilled as it ought to be. The plough is composed of three pieces of wood awkwardly fastened together, and imperfectly aided by the clumsy machinery of wheels. The districts best cultivated are the valleys of the Minho, those of the Oporto wine company of Upper Douro, and some portions of Tras-os-Montes and Beira; the remaining territory remains comparatively uncultivated. Where the soil is properly laboured and attended to, abundant crops of wheat, barley, maize, rice, and rye are produced. But enough is not raised to supply home consumption, about one fifteenth of the quantity used being imported. Artificial meadows are almost unknown, except in Minho. The cultivation of potatoes, however, has rapidly extended over the country, and hemp and flax of excellent quality are raised. But the chief attention of the Portuguese husbandman is directed to the production of those articles which find their most ready vent in foreign countries, or which are raised with the least labour. Of the first sort is their wine, which is produced chiefly in the northern provinces. The quantity usually made is about 80,000 pipes of red, and 60,000 pipes of white. The productions that require but little labour, such as chestnuts, almonds, oranges, lemons, and citrons, are also profusely raised, and, with the onions and garlic, form no small proportion of the aliment of the inhabitants. Olive-trees are plentiful, and the oil expressed from their fruit forms an important article of sustenance; and, though not of a quality or flavour that is relished for the table in foreign countries, it is a considerable article of export.

Animals. Generally speaking, cattle are not abundant in Portugal; for, with the exception of the grazing lands of the Minho, the Estrella, and Monte Junto, and a few other places, in which a beautiful and large breed of cattle is reared, the feeding is decidedly bad. Very little cheese or butter is made, these articles being mostly imported from England and Holland. Horses are far from being numerous, and they are of a small size, but very active. Mules, however, are of a first-rate breed, and they, in a great measure, compensate the deficiency. Sheep are reared to some extent, and their wool is inferior to none but that of Spain. There are numerous herds of goats, and abundance of swine of a peculiar species. Poultry are plentiful; and bees are bred to some extent. The rearing of silk-worms was once a considerable branch of industry; but the great injury sustain-

Statistics.

ed by the mulberry plantations during war has subjected it to many fluctuations. Birds are not numerous; but of wolves, wild cats, wild goats, wild boars, stags, and some other species of large game, there are a few in certain localities. Hares are rare, and rabbits are not so numerous as in Spain. Amphibious reptiles are not common, but vipers and venomous serpents abound in the mountains; the other parts of the country, however, appear to be free from them. There are several species of lizards; the insects of Northern Africa occur on the heaths; the butterflies of the south of France on the sides of the Estrella; and the scarabæi of the north are found on the mountains of Northern Portugal. The rivers are amply stocked with fish, and the coasts literally swarm with them. Pilchards are caught in immense quantities. Another very common fish is the pescada, a species of the gadus. Besides these, the kinds in greatest esteem and abundance are the sea and river eel, the sole, rodovalho, savel, ruivo, safio, cavalla, espada, and others.

Manufactures.

The manufactures of Portugal are comparatively unimportant; but the country has in general been underrated in this respect. No comparison can be instituted between its products of this sort and those of more industrious states; but if, notwithstanding the advantages England enjoys, the Portuguese have been able to compete with the English in different manufactures, it may be concluded that industry cannot be at so very low an ebb as is often asserted. However, almost all the finer fabrics are imported. At Alcobaça and Tomar cottons, at Guarda woollens, and at Guimaraens linens, are manufactured. The best goods that are made in the kingdom, as compared with those of other countries, are the cambrics, shirting and table linens, and sewing threads. Glass is manufactured at Leiria, and silk, paper, and other articles elsewhere; whilst in Lisbon there are manufactories of arms, cordage, hats, chocolate, earthenware, tin, copper, lace, mats, ribbands, soap, silk, cottons, with distilleries, tanneries, sugar refineries, and founderies. The Portuguese display considerable skill in working in gold and silver plate; and their taste in cabinet-work is said to be now much improved. Generally speaking, they manufacture most articles of recognised necessity with more or less skill. But neither the mines nor the fisheries are at all attended to as they ought to be. If the former were wrought, their produce might form important articles of commerce; and if the latter were prosecuted, as much fish might be caught as would render the importation of this article unnecessary.

Commerce.

The separation of Brazil from Portugal, together with the loss of her Indian possessions, have reduced the commerce of this country to a mere fragment of what it once was when her ports were the medium through which much of the produce of the east and of the west passed to other countries. Political events have also tended materially to depress the foreign trade of Portugal. Previously to 1820 it was very considerable, but since that memorable epoch in the annals of the country, it has sunk, comparatively speaking, to nothing. The chief articles of exportation are wines, lemons, oranges, figs, almonds, and other dried fruits; salt, oil, sumach, wool, and corkwood. The chief goods imported are wheat and other grains, dried cod, salted meat, butter, cheese, horses, oxen, mules, and other animals, medicinal and drying drugs, linseed-oil, planks, and other kinds of prepared wood, iron, steel, lead, tin, brass, copper, charcoal, tar and pitch, flax, hemp, and silk. Numerous articles of foreign manufacture were wont to be imported, and afterwards re-exported to foreign possessions; but this trade is of course annihilated, or nearly so.

There is a great deficiency of authentic documents regarding the commerce of Portugal. Those which can be relied on relate to periods too far back to admit of their being taken as evidence of the present state of trade, and those of a more recent date are imperfect. The following is a statement of the quantities of British and Irish produce and manufactures imported into Portugal in the year 1835; the declared value is given:—Apparel, slops, and haberdashery, L.13,938; arms and ammunition, L.1293; bacon and hams, L.1479; beef and pork, L.1454; beer and ale, L.2369; printed books, L.935; brass and copper manufactures, L.10,730; butter and cheese, L.94,052; coals, culm, and cinders, L.1561; cordage, L.165; cotton manufactures, L.796,002; hosiery, lace, and small wares, L.20,998; cotton, twist, and yarn, L.13,338; earthenware of all sorts, L.5171; woollen manufactures, L.350,715; fish, herrings, L.122; glass, L.11,753; hardwares and cutlery, L.31,469; hats, L.1990; iron and steel, L.49,484; lead and shot, L.8118; leather, L.6138; saddlery and harness, L.3212; linen manufactures, L.36,184; machinery and mill-work, L.5346; painters' colours, L.3805; plate, jewellery, and watches, L.1281; silk manufactures, L.19,485; soap and candles, L.482; stationery, L.9376; refined sugar, L.6840; tin, L.410; tin and pewter wares and tin plates, L.4176; woollen and worsted yarn, L.680; salt, L.150; all other articles, L.39,625. The total declared value of the whole was L.1,554,326. This was rather less than the amount of exports to Portugal during 1834, but more than for any preceding year. The goods imported from France in 1835 were, French and foreign merchandise, raw produce, L.42,284; manufactures, L.236,374; French merchandise, raw produce, L.27,247; manufactures, L.195,546. The total amount was L.501,453, about one third of that of Great Britain. The goods sent to the Portuguese dependencies are included. Portugal exported to Great Britain in 1835, wines of Portugal, 4,163,719 gallons; sheep's wool, 680,956 lbs.; bees' wax, eighteen cwts.; brandy, 1084 gallons; 2385 goats' skins; sumach, forty cwts.; raisins, twenty-four cwts.; olive oil, 270 gallons; oranges and lemons, 95,656 packages; figs, 828 cwts.; bark for tanning or dyeing, 1015 cwts.; cork, 59,910 cwts.; wheat 2157 quarters; and a few other articles. During the same year Portugal sent to France, raw materials and manufactures to the value of L.38,805; articles in a state fit for use or for consumption, L.41,425; total amount, L.80,231. But Portugal carries on trade with many other countries besides Great Britain and France. For her own products she receives from the Netherlands grain, cheese, colours, and dye-stuffs; from the north of Germany grain, linen, iron, tin, brass, and other metallic articles, and toys; from Denmark, grain and timber; from Sweden, grain, iron, steel, copper, and tar; from Russia, grain, hemp, flax, canvass, linen, cordage and tackling, timber, tar, tallow, furs, and the like; from Dantzig, grain, hemp, and timber. There is likewise a considerable intercourse with the United States, the foreign colonies of the kingdom, Brazil, and other places; but we have no data from which to estimate the extent and value of the foreign commerce. The internal trade, at the best unimportant, suffers from the want of good roads. Canals there are none, and the few navigable rivers are not so at all times, so that until proper roads are made or canals formed, the inland commerce of Portugal must continue to be very limited.

Government, laws, and religion.

The government of Portugal, once of the most absolute kind, is now a limited monarchy. The succession is hereditary, and extends to both sexes. The constitution of the kingdom, a sketch of which was laid before the cortes on the 7th of March 1837, is nearly a verbatim copy of that of 1822, an outline of which has already been given. The exceptions relate to the appointment of the senators, and the separation of the counsellors of state. The mode of election now adopted is the direct instead of the indirect. It is further provided, that no deputy can hold a public situation, and no officer in his district, no bishop in his diocese, nor any priest in his parish, is allowed to be chosen. The king and the royal princes are declared incapable of

Statistics. holding the chief command of the army or navy. The cortes have the right to choose a new dynasty should the reigning family become extinct. If the assembly of the cortes is dissolved, a new one must be called together within thirty days at the latest. The authority of the cortes is so great that the power of the sovereign is little more than nominal. The management of the affairs of the nation belongs to the counsel of state. There are six ministers, one for each of the departments of foreign affairs, the interior, finance, war and the colonies, marine, and justice. There are also boards of trade, of navigation, of agriculture, and of manufactures.

For the administration of justice there are two supreme courts of appeal; one at Lisbon, and the other at Oporto. There is also one for each of the provinces of Estremadura, Alemtejo, Algarve, Minho, Tras-os-Montes, Beira, and one for the comarca of Castello Branco in Beira. A court of cassation has been established in the capital. In criminal cases the proceedings are public; in civil matters the parties have the privilege of appointing an arbitrator, who is chosen from a society belonging to each city. Each of the six districts of the kingdom is divided into comarcas or jurisdictions, which are again subdivided into ciudades, villas, and provincial under-courts of justice, called concelhos, houras, contos, julgados, and behetrias, these being distributed in correiçoes, over which a corregidor presides as head judge, and who has a right to speak in the second instance, or court of judicature. The sub-judges are in individual places *juizes de fora;* but in all civil and criminal cases they speak in the first instance. In large towns the civil and criminal jurisdiction is under two *juizes da fora*, one of whom bears the title of *juiz da civel*, and the other that of *juiz da crime.* There are also in the towns and villages *juizes ordinarios*, or *juizes da paz*, a sort of justices of the peace. The number of persons connected with the administration of justice, those who have seats in courts, as judges, advocates, and others, is very great, and the course of law is tedious and expensive. The standard authority in matters of law and justice is the royal ordinances which Alphonso V. collected, and Emanuel I. printed. When this juridical code is not sufficient, the Roman law is appealed to; and in ecclesiastical matters the canon law is the recognised authority. The religion of the state is the Roman Catholic; but the exercise of all other forms of religion is permitted to foreigners. The supreme head of the clergy is the patriarch of Lisbon, who is always a cardinal. There are fourteen bishops under the archbishops of Braga and Evora, the former bearing the title of primate of the kingdom. The number of ecclesiastics and religious houses was at one time very great. In 1822 there were 132 nunneries, with 2980 nuns, 912 pupils and novices, and 1971 servant-women; and their revenue amounted to 432,189 milreis. The number of monasteries was 346, containing 5830 persons, who enjoyed an income of 784,513 milreis. The regular orders of monks have been reduced, and some other alterations relating to the church have taken place since Balbi published his Statistical Essay on Portugal, from which the above facts are taken; but we have no authentic data from which to draw up a correct statement of the present condition of ecclesiastical matters in Portugal. Religion has shared in the political fluctuations of the times.

Population and division. The following is a tabular view of the statistics of Portugal for the year 1835. The number of square miles and fire-places in the provinces and districts is given on the authority of official documents. The population has been estimated by multiplying the number of fire-places by four and a half, which is reckoned a fair average number of souls for each hearth.

Statistics.

	German Geographical Square Miles.[1]	Population.	Fire-Places.
In Europe.			
Province of Minho	126·	872,406	193,868
Province of Tras-os-Montes	191·75	331,213	73,603
Province of Upper Beira	405·	996,345	221,410
Province of Lower Beira		109,215	24,270
Province of Estremadura	416·68	790,655	175,701
Province of Alemtejo	483·75	314,311	69,847
Province of Algarve	99·	135,261	30,058
	1,722·18	3,549,406	788,757
To these there is to be added the			
Eastern District of the Azores	18·	90,000	20,000
Western District of the Azores	38·82	135,000	30,000
District of Madeira	18·50	112,500	25,000
District of Cape Verd Islands	149·	54,000	12,000
	224·32	391,500	87,000
In Africa.			
The settlement on the coast of Guinea	19·5	20,000	
The settlement of Angola	14,750·	376,000	
The settlement of Mozambique	13,500·	286,700	
	28,269·5	576,300	
In Asia.			
Government of Goa	223·	417,900	
Government of Dilli and Timor	85·	120,000	
Government of Macao	4·5	38,400	
		576.300	

The principal cities and towns having above 10,000 inhabitants are, Lisbon, 250,000; Oporto, 80,000; Elvas, 18,000; Coimbra, 15,200; Setuval, 14,820; Braga, 14,400; Evora, 10,500; Ovar, 10,300. In the colonies, Funchal, 20,000; Villa Nova de Goa, 18,500; Ponta Delgata, 18,000; Soanda de S. Paola, 18,000; Angra, 15,000; Cacheu, 15,000; S. Salvadore, 15,000; Mozambique, 12,340; Macao, 12,000.

The national varieties of the population are, Portuguese, 3,397,050; Free Blacks, 595,000; Gallegos, 50,000; Hindus and Malays, 420,000; Negro Slaves, 20,000; Chinese, 64,800.

The varieties of religion amongst the population are, Catholics, 3,782,050; Brahmins and Buddhists, 400,000; Foiten, 64,800; Fetishes, 400,000.

Instruction. In the year 1822 the statistics of education in Portugal stood thus. The university of Coimbra, founded in 1279, with six faculties, a preparatory college, sixteen hundred students; eight hundred and eighty-three elementary schools; three hundred and twenty-two Latin, and twenty-one Greek and rhetorical schools, together with twenty-seven for theoretical and moral philosophy. The total number of scholars, exclusive of students, was 31,280. To these are to be added the following establishments; the marine and royal academy at Oporto, which had three hundred and twenty-five scholars; the academy of Lisbon, with about as many pupils; the trades' school at Lisbon, with a hundred and fifty scholars; the Lisbon royal school for engineering, artillery, and drawing, with eighty scholars; and the military school at Luz, near the capital, with two hundred students. At Lisbon there are also a royal college for the nobility, and royal schools for the Arabic language, drawing, and architecture, and another for statuary; also an institution for instruction in copperplate engraving, an academy for teaching music, and some others. Surgery is taught at the university of

[1] A German geographical mile is nearly equal to $4\frac{3}{4}$ths English miles.

Statistics. Coimbra, and in several royal schools; in St Joseph's hospital in Lisbon; and in hospitals at Oporto, Elvas, and Chaves. The military school for mutual instruction, which the children of citizens are permitted to attend, had two thousand five hundred and sixteen scholars. There are other academies for instruction in science, geography, Portuguese history, navigation, marine affairs, artillery, and fortification; an institution for the encouragement of literature and other branches of knowledge at Lisbon; an academy for history and antiquities at Santarem; and an academy for scientific instruction in the small county-town of Tomar in Santarem. Portugal has seven botanic gardens, but some of them are of a very humble description; twelve museums of natural curiosities, open to the public; twelve collections of coins and other antiquities; eight observatories; a royal library at Lisbon, with eighty thousand volumes; and the university library of Coimbra, with sixty thousand volumes. In the fine arts the Portuguese have made but little advancement. There are comparatively few printing-presses in the country; and book-printing establishments on a respectable scale are only to be met with in Lisbon, Oporto, and Coimbra. Works of fiction, and books for edification in the Catholic faith, constitute half the yearly literary produce of the Portuguese. On account of their poverty, it has been customary to print scientific works at the royal expense. It is difficult to say whether the press be free in Portugal, at least according to our ideas of freedom. Liberty of the press was established by a decree in the year 1823; but the cortes annulled it, and appointed a commission of censorship.

Knights, royal titles, &c. There are seven orders of knighthood in Portugal, viz. the military order of Christ, established in 1319; the order of San Jago, for civil merit, founded in 1288; the order of Avis, for military merit, established in 1213; the military order of the tower and sword, founded in 1459, and revived in 1805–1808; the order of Villa Vicosa, or the immaculate conception, founded in 1818; the female order of Santa Isabel, established in 1804; and the order of the faith. In 1749, the king of Portugal received from Benedict XIV. the title of *rex fidelissimus;* and his Most Faithful Majesty styles himself "king of Portugal and Algarve, of both sides of the sea in Africa, lord of Guinea, and of the navigation, conquests, and commerce of Æthiopia, Arabia, Persia, and India." The heir to the throne is styled Prince Royal; his eldest son, Prince of Beira; the other royal children are called Infants and Infantas of Portugal. The present Braganza line of princes commenced with John IV. who was proclaimed king of 1640. The national escutcheon is a silver shield, with five smaller blue shields lying crossways. On each of these are five silver pennies, placed so as to form a Saint Andrew's cross. There is a red border containing the armorial bearings of Algrave, which are seven golden castles with blue towers. On the summit of the royal helmet there is a golden dragon; and the shield contains two dragons, each holding a flag, adorned with the emblems of Portugal and Algarve.

Finances. The revenues of the state arise from the extensive crown-lands, together with the hereditary estates of the house of Braganza, and the possessions of the first three orders of knights, the greater portion of which belongs to the crown. The other sources from which the government income is derived are, the customs, a property-tax levied from citizen and countryman, the tenth part of the amount of all goods sold, the profits of the "cross-bull," the impost on several requisites of life, the excise, the "decimas" or tithes of the clergy, stamps, lotteries, the mint, and others. Since the separation of Brazil from Portugal, and the attempt of Dom Miguel to maintain the sovereignty he had usurped, a great disproportion has taken place between the expenditure and the income; the latter being sometimes not equal to the half of the former. The consequence has been the accumulation of a national debt of enormous magnitude for so poor a country, and which there appears to be no immediate prospect of the government being able to extinguish, or even to lessen. We have no information that can be relied on as to its exact amount at present; but as it was stated to be three hundred and twenty-four millions of francs in the year 1832, we are rather below than above the mark in estimating it now, 1838, at four hundred millions of francs, or sixteen millions sterling. The income, as well as the expenditure, but particularly the former, has been subject to great fluctuations. These, however, are mainly to be attributed to the unsettled state in which the country remained for so long a period. In the year 1827, the income was 46,843,975 francs, and the expenditure was 62,162,363, so that there appeared a deficit of 15,292,388 francs. In 1829 the revenue was only eighteen millions, whilst the expenses amounted to forty millions of francs. The following is the budget for 1837–1838:

Income.....	9,294 cantos,	= 55,764,000 francs.
Expenditure.....	11,214	= 67,284,000 ditto.
Deficit.....	1,920 cantos,	= 11,520,000 francs.[1]

Army and navy. According to a decree dated on the 4th of January 1837, the organized army consists of, the infantry, thirty battalions, twenty of which are infantry of the line, and ten jägers, in all 21,560 men; the cavalry, eight regiments, four being lancers and four jägers, in all 3680 men; and the artillery, four regiments, and three batteries for the neighbouring islands, consisting of 2232 men. The combined military force of Portugal, therefore, amounts to 27,472 men; and there is, besides, an army of militia about 27,000 strong.

According to an official document of the year 1835, the naval force consisted of two ships of the line, four frigates, six brigs, eight schooners and cutters, eight gun-boats, eight transports, eight packet-vessels, and two steam-boats, in all forty-six sail.

People and language. The inhabitants of Portugal are generally a robust, yet not an industrious people. They are enterprising and persevering, patient in adverse circumstances, excessively attached to their own religion and customs, and, though temporary circumstances may seem to indicate the contrary, they retain a high sense of loyalty to their monarch, and of submission to their spiritual superiors. The Portugese language is derived from the Latin, of which it contains a great proportion of words, though mixed with many others of Arabic origin. In the construction of its sentences it very much resembles the Castillian; but the pronunciation of the syllables differs considerably, being in general less guttural; and there are many words introduced which seem peculiar to itself, and the derivation of which it is difficult to trace, though probably they are to be found amongst some of the tribes on the coast of Barbary. (R. R. R.)

[1] Weimar Almanac for 1838.

Portumna || Posen.

PORTUMNA, a small market town, in the county of Galway, Ireland. It is situated within half a-mile of the river Shannon, over which there is a bridge, and consists of a long line of cabins built without any regularity. It possesses a church and a Roman Catholic chapel. It is distant from Dublin 74 miles, and had a population in 1821 of 736, and in 1831 of 1122.

POSEGA, a city of the Sclavonian provinces of the Austrian kingdom of Hungary, the capital of a circle of the same name, which extends over 990 square miles, and comprehends one city, six towns, and 254 villages, with 74,200 inhabitants. The city is on the river Orlgava, and contains 410 houses, with 4220 inhabitants, who grow tobacco and silk. Lat. 45. 21. 30. Long. 17. 37. 25. E.

POSEN, one of the provinces of the kingdom of Prussia. It was formerly a part of Poland, but by the several partitions of that distracted country, and by the treaty of Vienna in the year 1815, has been guaranteed to Prussia. It is bounded on the north by west Prussia, on the east by Russian Poland, on the south by Silesia, and on the west by Brandenburg. It extends in north latitude from 51° 10′ to 53° 27′, and in east longitude from 15° 2′ to 18° 33′, and comprehends 12,836 square miles. It is generally a plain, with few elevations or even undulations. It consists for the most part of a sandy soil, though some of the marshy parts, when drained, form most excellent meadows for fattening cattle, and for the dairy. The chief product of the soil, as well as the chief food of the inhabitants, is rye, of which about ten times as much is grown as of wheat. Barley is to rye as four to ten, and oats as three to ten; thus the rye crops exceed the whole of the other. The agriculture was in a miserable state till the possession of the country was secured to Prussia by the treaty of Vienna, under the tranquillity and security created by which, it has been making surprisingly rapid improvement. Between 1802 and 1815, the stock of cattle had diminished; the cows, sheep, and horses being about one-third less in the latter than in the former year. Since 1815, an augmentation has again taken place, and the stock of that description in 1832, was found to have more than doubled. Many of the marshes had been drained and converted into excellent pasture, especially an extensive tract, by the construction of the Bromberg canal, which has improved the soil and formed a good communication through the Vistula with the Baltic sea. The forests, which cover one-twentieth part of the province, are a considerahle means of occupation, and a source of wealth. There are few manufactures in the province, and those have been mostly introduced by settlers from Germany since 1815. No part of Europe has shewn such an increase in the number of its inhabitants, as the province of Posen, but especially in the government of Bromberg, which is the northern division of it, in the ten years from 1817 to 1826, both years inclusive. By the census of the former years the government of Bromberg contained 261,368 souls, and that of Posen 579,753; and by that of the latter year Bromberg contained 330,235, and Posen 715,712; thus exhibiting an account by which, at the same rate, the population would be doubled in less than thirty-two years. In 1815 the German inhabitants were estimated at 140,000, and the Jews at 48,000, but it is probable their increase has been greater than that of the Poles, who formed the rest of the population. The religion of the Poles is mostly Catholic, that of the Germans chiefly Protestant. The former have a bishop, under the archbishop of Gnesen, with 581 churches, and several monasteries and nunneries, and two ecclesiastical seminaries. The latter have 101 churches, and two public colleges or gymnasiums. The nett revenue furnished by this province to Prussia in 1816, was about L.120,000, one-half arising from the forests, and other national estates, and the remainder from direct taxation. The whole province is divided into the two governments of Posen and Bromberg, and the former is divided into seventeen circles.

Posen || Position.

POSEN, a city, the capital of the Prussian province of the same name. It stands on a plain on the banks of the river Warthe, and is surrounded with walls, beyond which are some extensive suburbs. Having been burned down in 1803, its buildings are in a more modern style than formerly. It contains a cathedral, and twenty-five other Catholic churches, five monasteries, and four nunneries, a Lutheran, Calvinist, and Greek church, an episcopal palace, and theatre, with about 2500 houses, and 28,000 inhabitants. It has but little other trade beyond what arises from being the seat of the provincial government. The manufactures, though increasing and improving, are still insignificant, and mostly in the hands of the Jews, whose numbers in the city amount to near 5000, and who have a synagogue and some schools. Lat. 52. 22. Long. 17. 14. 30. E.

POSIDONIUS, a celebrated Stoic philosopher of Apameia in Syria, was the disciple and successor of Panætius, (Strab. xiv. 655.) The exact date of his birth and death are unknown, but he flourished B. C. 78, and came to Rome B. C. 51. (Suidas.) He resided principally at the island of Rhodes, and his reputation was so high that many of the young Roman nobility attended his lectures. He was visited by Cicero, B. C. 78, (Plut. Cic. 4. Cic. N. D. 1, 3), and by Pompey, B. C. 62. (Plin. vii. and Plut. *Pomp.* 42.) Posidonius went to Rome on an embassy respecting the affairs of the Rhodians, (Plut. Mar. 45), and probably at this time visited Spain, (Strab. xiii. 614), Gaul, (iv. 197), and Liguria, (iii. 165). He lived to the age of eighty-four, (Lucian, Macrob. 20), and was succeeded by his grandson Jason, (Suid.) Cicero (Div. i. 3), alludes to a work of his on divination, in five books; but he was not merely a philosopher, he was also an astronomer and geographer, who is frequently quoted by Strabo. He made an attempt to calculate the circumference of the earth, and also the diameter of the sun. (Strab. ii. 95, 138.) He treated at considerable length the phenomena of tides, and observed that they had diurnal, monthly, and annual periods, like the moon, (138, 174.) The scattered fragments of Posidonius have been collected and published, under the title, *Posidonii Rhodii reliquiæ doctrinæ, collegit atque illustravit J. Bake accedit Vrytlembachii annotatio*, 1810.

POSITION, CENTRE OF. From Archimedes to Doctor Wallis, writers have assumed, that there belongs to every *body* an individual point, where, for most purposes, the whole weight may be conceived to reside; and they have called it the *centre of gravity*. The learned Englishman, however, believed himself the first to accomplish a demonstration from the nature of gravity. (Scholium to Prop. xv. *De Centro Gravitatis.*)

But the same point is admirably connected with other properties and contingencies of the body than its weight; and hence different names have been considered as preferable by many writers, such as *centre of inertia*, &c.

And from viewing a body as composed of physical points, it is found that the relation of this centre to their positions is fertile in some of the most beautiful theorems in the mathematics; whence it has properly received the geometrical designation of the *centre of position*.

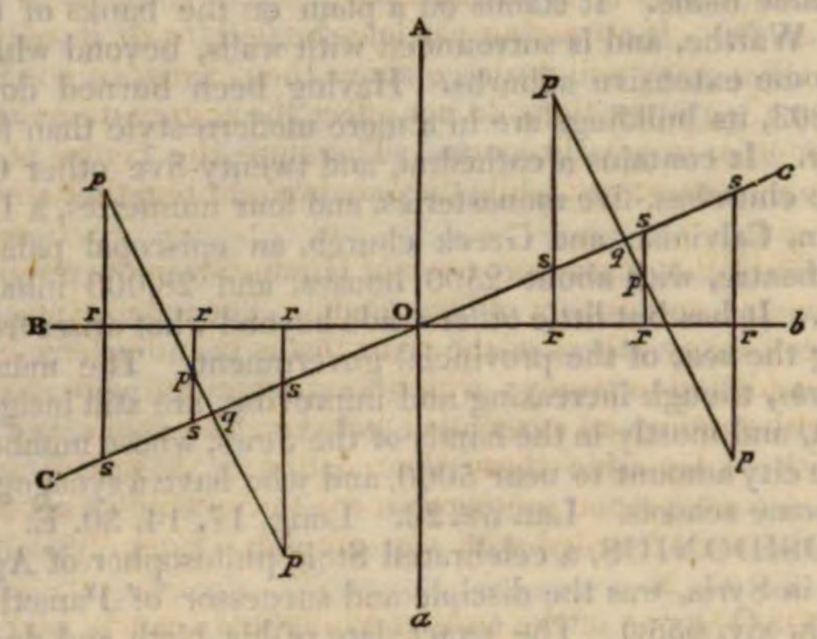
We here introduce it in this geometrical character; and shall demonstrate very briefly, but we trust sufficiently, a collection of elegant and most important properties, of which some are virtually proved elsewhere, in a manner more suited to the direct object of their introduction.

If there be any multitude of distinct points in space, it is clear that a plane may move, parallel to any given plane, until the collective distances of the points on one side of it be equal to those on the other.

Let a plane thus situated, relatively to a system of points, be called a plane of equidistance.

Position. Suppose two planes of equidistance, A and B, perpendicular to each other. Then, first, we shall find that any plane C which passes through their common section or axis, is also a plane of equidistance to the same system of points. For, let any plane, perpendicular to this axis in O, cut the planes A, B, C, in the straight lines A*a*, B*b*, C*c*, respectively. Then A*a* and B*b* are at right angles. Let a perpendicular from any point of the system meet the plane ABC in *p*. Draw *pq* at right angles to C*c*, and let it be positive when on the same side of the plane C as AO. Also draw *pr* perpendicular to B*b*, and meeting C*c* in *s*; and let *pr* and *rs* be positive when on the same sides of the planes B and C respectively as AO. The triangle *pqs* being given in species, *pq* is as *ps*, that is, as *pr*+*rs*; so that the sum of the *pq* is as the sum of the *pr* together with that of the *rs*.

Fig. 1.



But the *pr* are the distances of the points of the system from the plane B, which is a plane of equidistance; and therefore their aggregate is nothing. And again, the *rs* are as the *r*O, which are the distances from the plane A; and, having different signs on the two sides, their aggregate is also nothing. Thus the sum of the *pq* is nothing; and the plane C is a plane of equidistance.

Now let O move along the axis to make ABC a plane of equidistance. Then shall any plane K which passes through O be such a plane.

For let the plane K cut ABC in the line C*c*. The plane ABC, and the plane C, which cuts it perpendicularly in the line C*c*, are planes of equidistance; therefore, by what we have just proved, the plane K which passes through their common axis C*c* is also a plane of equidistance. Thus, to every system of points, there is a point through which every plane is a plane of equidistance. And there cannot be more than one. For if there were two, we might have through them two parallel planes of equidistance, which is manifestly absurd.

This single point has been called the centre of position.

Cor. 1. The difference of the centre of position from any given plane is an average of the distances of the several points of the system; the distances on different sides being distinguished by contrary signs.

For conceive the parallel plane of equidistance, at the distance D from the given plane. Let the distance of a point of the system from the given plane be denoted by D +*d*. Then *d* will vary its sign according as the point of the system and the given plane be on different sides of the plane of equidistance, or on the same side.

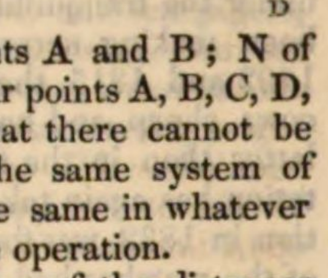
Now if there be *p* points in the system, the aggregate of their distances from the given plane will be *p*D, together with the aggregate of the *d*. But the collective *d* are nothing; so that it will be *p*D; or D is the average distance.

Cor. 2. If the average distances of the points of a system from three planes, perpendicular or inclined to each other, be given, the centre of position is given. For, by the distances of a point from three such planes, its position in space is given. Position.

Cor. 3. If the centre of position, and the multitude of points in each of two systems be given, the centre of the united systems is found in the straight line joining the given centres at distances from these reciprocally proportional to the multitudes.

Let P and Q be the centres of position of two systems of *p* and *q* points respectively. Let perpendiculars from P and Q meet any plane of equidistance in *a* and *b* respectively.

Fig. 2.



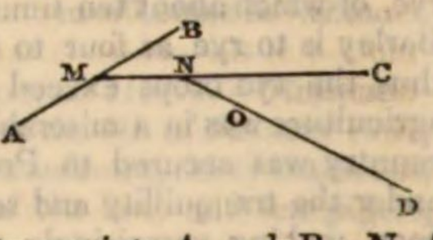
Then *p*.P*a*+*q*.Q*b* expresses the collective distances of the points of the united systems from the plane of equidistance, consequently the two terms are of opposite signs and equal magnitude.

And because P*a* and Q*b* are perpendicular to the same plane, they are parallel: so that P*a*, *ab*, *b*Q, are in one plane. Let O be the intersection of PQ and *ab*. Then PO and OQ are as P*a* and Q*b*; and since *p*.P*a*=*q*.Q*b*, we have also *p*.PO=*q*.QO, or PO : QO :: *q* : *p*.

Thus every plane of equidistance passes through the same point O, which is therefore the centre of position.

Scholium. Hence, if we have any points A, B, C, D, &c., bisecting AB in M, or making AM=$\frac{1}{2}$AB; again, making MN to NC as 1 to 2, or MN=$\frac{1}{3}$MC; and NO to OD as 1 to 3, or NO=ND, and so on: Then M is the centre of position of the two points A and B; N of the three points A, B, C; O of the four points A, B, C, D, and so on. And as we have proved that there cannot be more than one centre of position to the same system of points, the ultimate point must be the same in whatever order we take the given points into the operation.

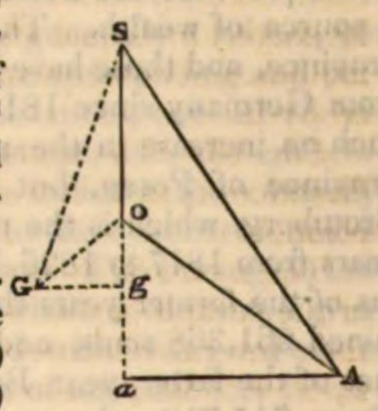
Fig. 3.



Cor. 4. The difference of the squares of the distances of the centre of position from the extremities of any straight line is an average of the difference of the squares of the several points of a system from these extremities.

Let SO be the straight line; A a point of a system whose centre of positiou is G; and A*a* and G*g* perpendicular to the extension of SO. Then AS^2—AO^2=*a*S^2—*a*O^2 =(*a*S+*a*O).OS; making *a*S and *a*O negative when measured contrary to the tendency OS.

Fig. 4.



Hence Σ(AS^2—AO^2)=Σ(*a*S).OS+Σ*a*O).OS. But, if there be *p* points, Σ(*a*S) is *p*.*g*S, and Σ(*a*O) is *p*.*g*O. Therefore, Σ(AS^2—AO^2) =*p*.(*g*S×*g*O).OS=*p*.(GS^2—GO^2).

Cor. 5. The squares of the distances of any points in space from their centre of position are together less than from any point in the surface of a sphere about this centre, by the square of the radius multiplied by the number of points.

For when G coincides with O, *g* is also there; and we have Σ(AS^2—AO^2)=*p*.OS.OS, or *p*.OS^2.

Cor. 6. If A, B, C, &c., express the number of points whose respective centres are in the positions A, B, C; and O be the centre of position of all the points united in one system; then, S being any other point,

A.SA^2+B.SB+^{2}C.SC^2=A.OA^2+B.OB^2+C.OC^2+(A+B+C)OS^2.

For, by Cor. 4, A(SA^2—OA^2)+B(SB^2—OB^2)+C(SC^2

Position. —OC²) expresses the excess of the squares of the distances of all the points from S over the squares of their distances from O, which (by the last cor.) is equal to (A+B+C). OS².

Cor. 7. In any system of points, the motion of the centre of position, in any given direction, is an average of their several motions in that direction.

For assume a plane perpendicular to the given direction behind all their motions. Let there be *p* points, and the sum of their distances from the assumed plane, at the beginning of the motion *pd*. Then the distance of the centre of position from this plane is *d*.

At any instant afterwards, let their united distances from this plane be *p*D, that of their centre of position being therefore D.

The aggregate motion of the system in the given direction has been *p*D—*pd*, or *p*(D—*d*), while that of the centre of position has been D—*d*.

Cor. 8. If the several points of a system be uniform as to their motion, the centre of position either rests or moves uniformly.

If it do not rest, whatever be its first tendency, it must persevere in the same. For as it begins without any motion perpendicular to this direction, the aggregate of the motions of the system in any direction perpendicular to this must be nothing, and therefore will continue nothing; so that the centre will never be taken out of its first direction. And as the motion of each point, estimated in this direction, is the same during a given time, the average, or the motion of the centre is the same; so that it traces its path uniformly.

Otherwise.

Because the motion of any point of the system, estimated in three different directions not in the same plane, is uniform in each; that of the centre of position is uniform in these directions, or is nothing. Hence it can have no motion other than uniform in direction and velocity.

Cor. 9. If a body, or system of bodies, be put in motion, and subject to no other disturbance than the action of the parts or bodies upon each other; the centre of position will either rest or move uniformly in a straight line.

For every particle is at first determined to a certain direction and velocity, or put in a condition of uniform motion. And the actions of material particles or bodies upon each other, (whether by impulsion, attraction, impact, or leverage,) are equal and contrary; so that the aggregate motion, and consequently the average motion, is not affected by it.

Cor. 10. The agregate momentum of a system, in any direction, is as if it were all collected into the centre of position.

The momentum in any direction is the united momenta of the several particles. Now, if there be *p* particles, and their several velocities in a given direction be denoted by v', v'', v''', &c.; these also represent their several momenta; and if we put $pv = v' + v'' + v''' + \ldots\ldots$; v is the velocity of the centre of position. Thus the aggregate momentum is as if every particle were in this centre.

Scholium. When the system is connected these parallel momenta compound a force in the given direction, which passes through the centre of position, or centre of gravity; and is equal to the sum of the several forces. So that the impact of the system is as if all were collected in the centre.

Cor. 11. If a body be left to itself in a state of rotation, the axis of rotation will pass through the centre of position.

For when there is rotation, no point out of the axis can either rest or move in a straight line. Therefore the centre of position will be in the axis. Positra ‖ Post.

Cor. 12. If attracting particles be left to their mutual attraction, they will coalesce about their centre of position.

For their attractions do not affect the aggregate or average motion in any direction. Therefore the centre of position remains at rest while they are brought together around it. (o. o. o.)

POSITRA, a sea-port town of Hindustan, in the province of Gujerat, and district of Okamindel. The inhabitants, like those of many others of the coast towns in India, have been long addicted to piracy; which was prosecuted with ardour, notwithstanding an agreement between the chiefs and the British to lay aside these depredations. A British force was in consequence sent against the town, which was taken, and the walls levelled with the ground. Long. 69. 17. E. Lat. 22. 23. N.

POSON, one of the smaller Philippine islands, near the west coast of Leyta. Long. 124. 24. E. Lat. 10. 43. N.

POSSESSION Island, in the South Pacific Ocean, discovered by Monsieur Marion in 1772. It is of a round form and mountainous. Long. 41. 40. E. Lat. 46. 30. N. There is another island of this name in the South Pacific Ocean, near the north point of New Holland. It was taken possession of by Captain Cook in the name of Great Britain. Long. 218. 21. E. Lat. 10. 33. N.

POSSESSIVE, in *Grammar*, a term applied to pronouns, which denote the enjoyment or possession of any thing either in particular or in common; as *meus*, mine; *tuus*, thine; *suus*, his own, her own, its own, or their own.

POSTERIOR, a term of relation, implying something behind, or that comes after, another. In this sense it is used in opposition to *prior* and *anterior*.

POSTERN, in fortification, a small gate, usually made in the angle of the flank of a bastion, or in that of the curtain, or near the orillon, and descending into the ditch; by which the garrison can march in and out, unperceived by the enemy, either to relieve the works, or to make sallies against an enemy. The word is also used in general for any private or back door.

POST-HORSE, a rocky inlet in the Eastern seas, near the west coast of the island of Celebes. Long. 119. 18. E. Lat. 5. N.

POSTHUMOUS, a child born after the death of his father, or taken out of the body of a dead mother; and hence frequently applied to the works of an author not published until after his decease.

POSTIL, a name anciently given to a note in the margin of the Bible, and afterwards to one in any other book posterior to the text.

POSTILLIONS, a chain of rocks in the Eastern Seas, about 60 miles in length from north to south. Long. 119. 18. to 119. 54. E. Lat. 6. 15. to 6. 48. S.

POSTLIMINIUM, amongst the Romans, the return of one who had gone to sojourn elsewhere, or had been banished, or taken by an enemy of his own country or state.

POST, a word derived from the Latin *positus*, set or placed. It is used in several different meanings, but all of them referring either immediately or remotely to the primitive sense of *position*. Thus the word post signifies a stake, or piece of timber set upright; a station, particularly a military station; an office or employment; an operation in bookkeeping; a conveyance for letters or dispatches; a particular mode of travelling.

POST-OFFICE.

History. It has been usual to trace the origin of posts to a remote antiquity; certain establishments, having something in common with the modern post system, being found to have existed at an early period of the world's history. Herodotus and Xenophon mention that, amongst the ancient Persians, stations were appointed at intervals along the great roads of the empire, where couriers were constantly kept in readiness to convey dispatches and intelligence. Similar institutions, as we learn from Suetonius, were maintained amongst the Romans in the time of Augustus, and such probably existed much earlier.

But although the *name* of the *post* may be traced to this source, (from the Latin word *positus*, whether as applied to the accommodation and means of transport *placed* at intervals for the service of the couriers, or to the couriers themselves, placed or *posted* at the several stations,) such institutions obviously bear but a general resemblance to the post-office of the present times. The couriers were mere state messengers, the communication only to and from the seat of government; nor, as far as appears, was there any regular machinery for the receipt and delivery of letters, so essential to the idea of a modern post establishment.

The posts which were first instituted in the kingdoms of modern Europe, as those by Charlemagne and Louis XI. of France, the Emperor Charles V., and some other sovereigns, differed little, if at all, from those now described. It is indeed probable, that whenever the posts or couriers were appointed to perform their journeys at stated periods (which, as soon as the occasions for employing them became frequent, would be found at once the most economical and effective mode,) such a convenient means of conveying correspondence, though primarily intended only for state purposes, would soon come to be used by individuals. Houses of call, for the receipt and delivery of letters, would in process of time be established by custom, if not by regular appointment; and in this way might grow up the modern post system. The earlier posts instituted in Europe, however, were in general but of temporary duration; their existence being dependent sometimes on occasion, sometimes on the disposition or policy of particular monarchs.

Between the end of the fifteenth and beginning of the seventeenth century, indeed, there were several members, in succession, of the noble family of Taxis in Germany who applied themselves in a remarkable manner to the establishment of posts, and the office of postmaster-general of the empire was eventually conferred on the family as a hereditary fief. As certain posts settled by this family (at a period preceding that in which the modern post system was generally introduced in Europe,) continued permanent, such posts may be considered (unless, indeed, they were at first formed on the modern plan (as affording an instance of transition from the ancient to the modern system. In other cases, however, there is no room for representing the latter as having grown out of any extension, adaptation, or improvement of the former. Thus, in our own country, the insular position of which made our sovereigns less anxious about intelligence from their frontier, nothing of the nature of a public post establishment can be said to have existed, (with an immaterial exception in the reign of Edward IV.) until after the modern form was introduced, the rise of which it is a matter of no difficulty to explain. The conveyance of letters, indeed, is what must inevitably become, in the course of human transactions, as much matter of necessity, as the conveyance of persons or of commodities; and the same circumstances which generate the formation of roads and bridges, and give existence to the trade or occupation of carrier, shipmaster, or innkeeper, must necessarily lead to the employment of the post messenger, under greater or less degrees of system and regularity. History.

History, more attentive to record the transactions of monarchs, than the steps by which communities effect their advancement and improve their conveniences, furnishes nothing beyond an incidental notice of the modes by which the circulation of correspondence was conducted, before it became matter of state regulation. Of course, however, it is not to be supposed that no such modes existed, or that notices of these are entirely wanting. The conveyance and delivery of letters was often part of the regular occupation of travelling pedlars and others whose business led them to perform stated or frequent journeys. When commerce began to advance, regular conveyances for correspondence were established between some of the principal trading cities, either by the municipal authorities,[1] or by concert of private individuals or associations. A permanent establishment of messengers for the conveyance of letters was attached to the university of Paris, from the beginning of the thirteenth century, and, indeed, was not abolished until the year 1719, long after a general post had been settled in France. Other universities were similarly provided.[2] In some instances powerful and opulent individuals established posts, either as a mercantile speculation, or for the convenience of any district in the prosperity of which they took an interest. But although the conveyance of correspondence was thus brought to some degree of system, or rather prevailed under a variety of systems, even in places where the state authorities had not yet provided any public establishment for this purpose, it is easy to see that communication, especially between more distant places, must have been slow, irregular, and insecure. The advantage and even necessity of having a uniform and legalized system of post conveyance, could not have failed to present itself to the eyes both of subjects and rulers; although it may be a question whether the sovereigns who first established such systems in their dominions were, in general, moved so much by large and enlightened views of public benefit, as by the wish to create, according to the practice so usual in that age, a lucrative trading monopoly in behalf of some of their favourites.

The establishment of the modern post system, then, in regard to the mode of its taking place in some of the principal countries of Europe, is not properly to be viewed as of the nature of a political or civil invention; being merely the assumption, on the part of the state, of the conduct of a particular department of human affairs, which had grown up with the progress of society, but could no longer be com-

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[1] Kennedy, in his annals of Aberdeen, mentions that the magistrates of that city, in the year 1590, appointed a person to convey their dispatches to and from Edinburgh and other places of royal residence. This functionary bore the style of *council post*, and was arrayed in a garment of blue cloth with the town's armorial bearings in silver upon the sleeve. Vol. i. p. 262.

[2] In the act of Queen Anne there is a special clause, permitting letters to be sent to and from the universities of Oxford and Cambridge, "in manner as heretofore hath been used, anything herein to the contrary notwithstanding." The privilege has since ceased to exist.

History. petently managed by individuals, whether acting severally or in concert. And accordingly, in acts and ordinances relative to posts, there is not so much in the shape of *offer* of a new species of accommodation, as of *prohibition* against procuring the same accommodation by any other than the offered means.

The notices we possess of the early history of the British post-office, are but meagre and indistinct. What they amount to may be stated as follows. There was a chief postmaster of England in the reign of Elizabeth, if not earlier, Randolph having that title assigned him by Camden (1581); but his duties, of which that author takes no notice, probably related but partially, if at all, to the conveyance of correspondence.[1] James I. appointed a postmaster to take charge of the conveyance of letters to and from *foreign parts;* and different persons are named as successively enjoying this office during his reign and that of his son Charles. In 1635 Charles established a letter office for England and Scotland, which may properly be regarded as the origin of the British post-office. The persons to whose management it was committed, were directed to establish, within a limited time, a post from London to Edinburgh, one to Westchester and Holyhead, and another to Plymouth and Exeter; and the journey from London to the termination of each of these lines and back, was appointed to be performed in six days. Bye-posts were ordered to be established, and other principal lines opened up as occasion might arise; and conveyance of letters otherwise than by post was now prohibited within the kingdom, as it had formerly been between the kingdom and places abroad.[2]

In the year 1642, a committee of the House of Commons was appointed to report on certain matters connected with the post-office; and the subject continued afterwards, at intervals, to engage the attention of the House. In 1644, Mr. Edmund Prideaux, who afterwards held the office of attorney-general to the commonwealth, and who had been chairman of the committee of 1642, was elected postmaster-general by resolution of both Houses of Parliament; "in the execution of which office," says Blackstone, "he first established a weekly conveyance of letters into all parts of the nation, thereby saving to the public the charge of maintaining postmasters to the amount of L.7000 per annum."[3] This has been interpreted to mean (whether correctly or not) that the charges of the post-office previously to the improvement effected by Prideaux, exceeded its income by the sum mentioned.[4] Be this as it may, there seems to have been, from the period of these improvements, a considerable profit realised from the posts. Whether from a desire to share in this profit, or for other reasons, the Common Council of London, in the year 1649, set about establishing a separate post-office; an attempt, however, which was promptly put down by a resolution of the House of Commons, declaring that "the office of postmaster is and ought to be in the sole power and disposal of Parliament."

It appears likely, that, originally, any surplus revenue which might be obtained from the posts, was allowed to belong to the postmaster, and even that the charges for postage were fixed by him, although subsequently regulated otherwise. Thus, the proclamation of Charles I. in 1632,[5] forbidding the conveyance of letters abroad otherwise than by the post, refers to the act of his father, by which the post to foreign parts was first established; and narrates, that that act gave to the postmasters "power to take moderate salaries," meaning, it might be supposed, to charge such rates as would afford moderate salaries; and a little later, in regard to the case of Wytherings, from whom the office of postmaster had been sequestrated by proclamation in 1640,[6] we find the Commons in 1642 declaring the sequestration a grievance and illegal, and "that Mr. Wytherings ought to be restored into the possession of his place as postmaster for foreign parts, and to the mean profits received since he was out of possession, deducting the reasonable and usual charge of execution."[7] At a later period, commencing probably about the time when Prideaux held the office of postmaster, it was the custom to farm the revenues of the post-office.[8]

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The post rates first established were twopence for a single letter for a distance under 80 miles, fourpence from 80 to 140, and sixpence above 140. About the year 1654, they were fixed at twopence for 80 miles, and threepence for a greater distance.

Under the authority of the Protector and his Parliament, some material changes were again made in regard to the management of the post-office in 1657, by which it was brought nearer to the model under which it has more latterly subsisted. An advantage held forth in an ordinance[9] passed on this occasion, as one that was to be derived from the establishment of posts, is worth noticing, namely, that "they will be the best means to discover and prevent many dangerous and wicked designs against the commonwealth." Possibly a hint from Charles, some twenty years before, as to making the post-office afford this sort of convenience, had not been very well taken. It does not appear, however, that either at this or any subsequent time, the secrecy of correspondence passing through the British post-office, was ever violated to serve the purposes of government.[10]

The arrangements made in 1657 were confirmed, and some further improvements effected, at the Restoration.[11] In 1663, the post-office revenues were assigned to the Duke of York and his heirs male,[12] and again settled, after his accession to the throne, on the king and his successors, thus becoming part of the hereditary revenues of the crown. From this time nothing of importance seems to have occurred in the history of the post-office, until the year 1710, when was passed the statute 9 Anne, ch. 10, which may be called the charter of the British post-office.

In the system of posts established by Charles I. in 1635, provision was made for the conveyance of letters between England and Scotland, but the royal ordinance makes no mention of an *internal* post for the latter kingdom. The postage between the two capitals was then eightpence; in the time of Cromwell it was fourpence. After the Restoration, the postage to Berwick was fixed at threepence. In the latter part of this century, however, there was a postmaster-general in Scotland, and posts on some of the principal lines of road. In 1667, a post was established to pass between Edinburgh and Aberdeen twice a-week, and one

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[1] The name of *posts*, as already observed, had its origin in relation to an arrangement of *travelling stations*, a relation which it continued to preserve; and before the establishment of *letter* offices, the *postmaster* (a use of the term not yet obsolete), was the person who provided the means of conveyance from one station to another. The necessity of regulation and superintendence in regard to an office of this kind, led to the appointment of a *postmaster-general*, to whom such superintendence was committed. For some time after the establishment of letter-offices, the duties of postmaster, in the earlier and later meaning of the term, were conjoined.

[2] *Fœdera*, tom. xix. p. 649.

[3] *Com.* book i. ch. 8.

[4] It is stated that the revenue in 1644 was estimated at L.5000. *Macpherson's Annals of Commerce*, vol. iii. p. 408.

[5] Rymer's *Fœdera*, tom xix. p. 385.

[6] *Fœdera*, tom. xx. p. 429.

[7] *Journals*, 28th March, 1642.

[8] They were farmed in 1654, by a person named Maubey, or Manley, for L.10,000. In a view of the public revenue made up by a Committee of the Commons in 1659, there is an item, "By postage of letters in farm, L.14,000." *Journals*, vol. vii. p. 627.

[9] Scobell's *Acts*, 1656, p. 511.

[10] It is implied by an *exception* in the declaration made by every post officer at his entrance into office, that a letter may be opened by warrant of a Secretary of State.

[11] 12th Charles II. c. 35.

[12] 15th Charles II. c. 14.

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about the sametime, between Edinburgh and Inverness once a-week.[1] Somewhat earlier, (in 1662) a post was established between Ireland and Scotland, and the privy council gave Robert Main, then postmaster-general, an allowance of L.200 sterling, to build a packet boat for conveying the mails between Portpatrick and Donaghadee. The postage to Ireland was sixpence. But whatever was effected in these respects in Scotland, seems to have been entirely by the authority of the local executive, or the magistrates of the principal towns; the first legislative act appointing an internal post in Scotland, being that of the 20th of the 5th Session of the 1st Parliament of William III., passed at Edinburgh in 1695. The preamble of this act embodies the statement that, "for the maintenance of mutual correspondence, and preventing of many inconveniences that happen by private posts, several public post-offices have been heretofore erected for carrying and receiving letters by posts, to and from most parts and places of this kingdom." This act, as also that of the 12th Charles II., was repealed (unless so far as re-enacted) by the statute of Anne above referred to.

The act of Queen Anne established a general post-office for, and throughout the kingdom of Great Britain and Ireland, and the colonies in North America and the West Indies, with one master of such office, who was to bear the name and style of her Majesty's postmaster-general. The postmaster-general was empowered to keep one chief letter-office in Edinburgh, one in Dublin, one in New York, and others in the West Indies. In the year 1784, however, about which time there prevailed in Ireland a remarkable jealousy of any assumption of superiority on the part of Britain, an act was passed by the Irish parliament, by which, as well as by certain corresponding acts[2] on the part of the British legislature, the Irish post-office was withdrawn from the government of the British postmaster-general, and placed under an independent officer styled "his Majesty's postmaster-general for Ireland;" but the two offices were, agreeably to the recommendation of the commissioners of revenue inquiry, again consolidated by an act passed in 1831;[3] and at the same time the office of deputy postmaster-general of Scotland was abolished. The whole affairs relating to the post-office throughout the kingdom, were thus put under the direct management of the London board; but the secretaries at Edinburgh and Dublin are still the organs of communication with the country offices, and exercise a general administrative superintendence in their respective divisions of the kingdom.

During the period for which an account has now been given of what may be called the *constitutional* history of the post-office, a very great increase has, as may be supposed, taken place, in the speed of conveyance, and the extent of the communications maintained.

For a considerable time after the first establishment of the post-office, there were no relays of post-boys or horses at different stages; one man and horse accomplishing the whole ride, and taking the necessary rests by the way. The post between Edinburgh and Aberdeen stopped one night at Dundee, and another at Montrose. This system continued in Scotland till about the middle of the last century. Until 1763, the communication between London and Edinburgh was only three times a week; but in that year it was made to be five times a week. At first, the mail was 85 hours in travelling from London to Edinburgh, and 131 hours in returning. In 1757, the time was shortened to 82 hours in the one case, and 85 in the other. Latterly, the journey has been performed by the mail coach, in 42 and 45 hours, the 42 being farther reduced, by the use of the curricle from Morpeth, now discontinued, to 40. Mails are at present conveyed partially by railway, from London to Edinburgh in 33 hours, and from Edinburgh to London in 36. History.

Until the year 1788, there was no direct mail from London to Glasgow. Previously to that period, the course of post had been five days, the letters being sent round by Edinburgh; and as no mails were dispatched from the latter city upon Sunday, there was in consequence one arrival the less at Glasgow each week. Dr. Cleland[4] tells, that, when a direct mail conveyance was first established (a little before the time now spoken of) from London to Carlisle, the mail for Glasgow, that otherwise would have been the one delayed on Sunday at Edinburgh, was transmitted through Carlisle to Glasgow in four days; notwithstanding which the mails of the other days were allowed for a year to be carried round by Edinburgh; and the delay, the means of saving which was thus shewn in regard to one day in the week, acquiesced in for all the other days.

One of the most remarkable steps which the post-office has made in advance, is usually and justly considered to be the adoption of Mr. Palmer's celebrated plan in 1784. The chief part of this plan, as is well known, was, to have the mails conveyed in charge of an armed guard, by the stage-coaches, (which thus became *mail* coaches) instead of by a boy on horseback, or mail cart, as formerly. The credit due to Mr. Palmer, is not perhaps so properly that of having discovered a means to an end, as that of having conceived and aimed at the end itself; for it is not easy to see how the increased speed and regularity, which were in effect obtained, were bound up in his specific proposal, or how (as the advantages of that proposal are sometimes described) the post-office was at once to borrow regularity from the stage-coaches, and the stage-coaches from the post office. Mr. Palmer's merit really consisted in seeing that a greater degree of speed and regularity in post conveyance was possible, which nobody saw but himself; and in catching the hint from the stage-coaches, which nobody else caught. The advantage of employing the stage-coaches instead of conveyances furnished expressly by the post-office, would seem to resolve mainly into the point of economy.

Mr. Palmer was afterwards appointed controller of the post-office, in which capacity he is understood to have made some important improvements in the internal details and arrangements.

The first mails on Mr. Palmer's plan, were the Bath and Bristol, on the 2d August 1784. Previously to the adoption of this plan, the ordinary speed of the post is said to have been but about three miles and-a-half in an hour. After that, the speed was doubled. At present, the average speed of the mail coaches, is eight miles seven furlongs, the highest reaching to ten miles five furlongs. This is exclusive of stops.

The number of miles travelled over in England and Scotland, by the mail coaches in 1833, was 5,911,006; in 1836 it was 6,643,217.[5]

Mails were first conveyed between Liverpool and Manchester, in 1828. Three communications took place daily between these towns, until September 1835; afterwards there were four, and latterly there have been six, from Liverpool to Manchester, and five the contrary way. The important line of railway connecting London with Birmingham, Liverpool, and Manchester, and extending northwards to Preston, having lately been opened, mails are now regularly transmitted by it from the capital to the various towns in the extensive and populous district through which it passes, and onwards to Scotland and Ireland, from its terminating points in each direction. A travelling post office is conveyed along the

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[1] The former was established by the magistrates of Aberdeen, but was transferred to the direction of the Scotch postmaster-general in 1674.—Kennedy's *Annals*, vol. i. p. 262.

[2] 24 Geo. III. c. 6, 8.

[3] 1 Wm. IV. c. 8.

[4] *Statistical Account of Glasgow.*

[5] *App. to First Report of Postage Com.* 1838, No. 23.

History. line, in which letters are sorted during the passage, the advantage of which will be afterwards explained. The only, or principal, other line of railway by which mails are at present conveyed, is that connecting Carlisle and Newcastle, but this mode of carriage must of course extend itself as new lines are completed. A late act[1] empowers the postmaster-general to require railway proprietors to carry the mails at a rate fixed by arbitration. The effect of the rapid transmission of correspondence by railway, increased as that rapidity yet may be, if there were added such a reduction of postage as has lately been proposed, would almost be that of bringing the inhabitants of the extremes of the kingdom into personal communication. The revolution which may thus be produced on trade, science, government, and social economy, it is hardly possible to calculate.

In the course of the last twelve or fifteen years, the facilities of communication, both inland and foreign, have been materially extended, by reduction of postage duties and otherwise.

Until the year 1827, letters passing between Britain and Ireland had been charged the added amount of the British and Irish land postage, severally taken. From that year, the rate has been calculated the same as if such letters had been conveyed the whole distance in Great Britain. At the same time, the law which required double postage to be charged on one sheet of paper with two letters written on it, or a letter and invoice, &c. was repealed, and a single sheet declared to be in any case but a single letter.[2]

In the year 1835 it was enacted,[3] that after an agreement shall have been made with the post-office of any foreign kingdom or state, it shall be optional with persons sending letters by post to such foreign kingdom, to pay both the British and foreign postage at the time of sending the same, or to send the same without payment of any part of the postage, or to pay the British postage only: persons residing in foreign kingdoms having the same option. Following out the powers given by this statute, a convention was entered into, and signed at Paris, on the 30th March 1836, between his Britannic Majesty and the King of the French, in which the requisite arrangements are made for giving the proposed option as to payment of postage on all correspondence between France, on the one hand, and Great Britain and Ireland, and those British colonies and possessions where the post-office of Great Britain has established post-offices, on the other. The postage between Paris and the British frontier is fixed at one franc, between London and the French frontier at tenpence, and in proportion for other distances in each kingdom. And though under the present arrangements the option of sending letters *without* payment is confined to those for France alone, letters may be sent through France, paid for the full distance, to any post town in Switzerland, Sardinia, Central Germany, or Bavaria; also to the Southern Italian States, as far as Sarzane, the Italian frontier of Sardinia, and to Austria, Bohemia, Venice, &c., as far as the French frontier offices of Huninguen or Forbach.

By the same statute,[4] the postage on letters sent by private ship from the United Kingdom to places beyond seas, (which until then had been *one-half* of the *packet* rates), was fixed at the uniform rate of eightpence, single, on letters posted at the port, and one shilling if posted at any other part of the kingdom. Letters were at the same time permitted to be sent abroad, from any port, by a private vessel, without passing through the post-office, or from one port to another, within the United Kingdom, by private ship, at a sea postage of eightpence.

In 1835, a post communication was opened up between Britain and India, through the Mediterranean, by which the course of post with that part of the world has been very greatly shortened. Letters for India can also be forwarded through France by steam boats sailing three times a month from Marseilles. History.

Very important facilities and immunities have recently been given in regard to the transmission of *newspapers*.

At first the transmission of newspapers seems to have been a privilege confined to certain officers in the post-office. In 1763 an act was passed,[5] giving the sanction of law to what then seems to have become the current practice, namely, that of allowing newspapers to be sent free by members of Parliament and certain public officers, when signed on the outside by their hand, or *to* such members at any place of which they had given notice in writing to the postmaster-general. By gradual relaxations, the restrictions on the free transmission of newspapers degenerated into a mere form, that of printing or writing a member's name on the cover; and in 1825 an act[6] was passed, rendering even the observance of this form unnecessary. The same act, as subsequently amended,[7] allowed printed newspapers to be sent to the colonies, by the packet boats, at a postage of one penny halfpenny each paper, and colonial newspapers to be brought to Britain and Ireland, by packet or private ship, at a postage of threepence. In 1834[8] the postage on newspapers sent to the colonies by packet, and on colonial newspapers brought by packet, was wholly taken off. At this time, too, a most important enactment was made in regard to the transmission of newspapers to and from foreign states. Hitherto the power of such transmission (unless at an expense amounting to a prohibition) had been enjoyed exclusively by certain officers in the post-office, from whom individuals could only obtain the accommodation at a considerable charge. By the statute now passed, British and Irish newspapers were allowed to be sent to foreign states, and foreign newspapers received into Britain and Ireland at a postage of twopence for each paper. A later statute[9] extends the accommodation still farther, by a clause authorising the postmaster-general to allow newspapers to pass free to and from such foreign states as grant a corresponding allowance in regard to Britain; or even, if he sees fit, without such a reciprocal arrangement on the part of other states; or to impose in any case an equivalent duty. And, by virtue of these provisions, there is now a free transmission of newspapers between Britain and the following states and places abroad: viz. Hamburg, Bremen, Cuxhaven, Denmark, Spain, Greece, Ionian Islands, Hayti, Buenos Ayres, Brazil, Columbia. British newspapers are sent to France without any charge in this country, but pay four centimes there. Newspapers *from* France are charged one halfpenny in Britain.

At this time also newspapers to or from penny post towns, passing through the general post, were freed from penny postage.

To these facilities for the circulation of newspapers is to be added that arising from the important alteration in the stamp laws, by which the duty on newspapers was reduced, from and after the 15th September 1836, from $3\frac{1}{2}$d. (nominally 4d.) to 1d.[10]

Business and establishments.

In proceeding to give a brief account of the post-office business and establishments, it may not be improper to advert to the new and improved accommodation lately provided for the use of this department, in the metropolis. About the year 1815 the premises in Lombard Street being found, after every possible enlargement, to be quite inadequate for the uses they were required to serve, measures were taken for the erection of a more ample, commodious, and elegant structure. It was not, however, until Septem-

[1] 1 and 2 Vict. c. 98. [2] 7th and 8th Geo. IV. c. 21. [3] 5th and 6th Will. IV. c. 25. [4] 5th and 6th Will. IV. c. 25.
[5] 4th Geo. III. c. 24. [6] 6th Geo. IV. c. 68. [7] 7th and 8th Geo. IV. c. 21.
[8] 4th and 5th Will. IV. c. 44. [9] 6th and 7th Will. IV. c. 54. (1836.) [10] 6th and 7th Will. IV. c. 76.

Business and establishments.

ber 1829, that this purpose was finally accomplished, and the new building brought into a state of readiness for the public service. It is constructed of Portland stone, after a design by Mr. Smirke, and is in length about 390 feet, width 130, and height 64. The principal front, towards the west, in St. Martin's-le-grand, is composed of three Ionic porticos, that in the centre surmounted with a pediment. The middle space in the interior, lying between the principal and back entrances, is occupied by a hall of eighty by sixty feet in extent, having a range of columns and pilasters on each side. On the right, or south side of this hall, are the secretary's, accountant's, and receiver-general's chambers, together with the foreign letter and twopenny post-offices. The opposite side contains the inland, the newspaper, and the ship-letter offices. The mails, inwards and outwards, pass through a vestibule on the eastern front, communicating with the inland office. The latter is nearly ninety feet in length, and about fifty-six in width; the letter-carriers', or newspaper office, adjoining the inland, 103 by 35. The building contains a variety of other apartments for the different branches of the service, general and particular. To avoid the inconvenience and confusion of communication, through the public hall, between the departments on each side of it, the letters are conveyed from the one to the other through a tunnel below, by means of a curious machinery contrived on purpose.

The office at St. Martin's-le-grand, may be said to consist of two distinct establishments; one is the *general* post-office, properly so called, or that devoted to the post business of the empire in general; the other is just the post-office of *London*. In the first division, under the postmaster-general, are the departments of the secretary, accountant, the dead letter, mail coach offices, &c. The principal departments of the second division, are the *inland* and *twopenny post* offices. The former has charge of the dispatch of the London letters and newspapers, and of those from abroad, passing through London, to all parts of the kingdom. It also manages the delivery of all those arriving at, and destined for London.[1] Subject to this department there are seventy receiving-houses within a circle of three miles from the office. Within this circle letters are taken in and delivered without any charge beyond the general post rates. The inland office employs eighty-four clerks, two hundred and ninety-one subsorters and letter-carriers, and about fifty messengers, stampers, &c. The most arduous business of this department, that requiring the greatest energy and rapidity, is the dispatch of the mails, in number twenty-nine, at eight o'clock each evening. So near has the time up to which letters and newspapers are received, been brought to the hour of dispatch, and such is the increase of business, particularly in regard to newspapers, that it almost exceeds the utmost efforts of the persons engaged to accomplish the duties within the limited space. By an account kept on the 19th February 1838, it was found that of 47,795 letters received at the inland office, up to fifteen minutes before eight, only 9,428 had arrived before half-past five, and 9,842 came in after seven. The sum of 6d. charged on each letter taken in during a limited time each day after the receiving box is shut, amounts to above L.1000 a-year. Sometimes 30,000 newspapers are received within the last fifteen minutes allowed for taking them in. The letters are successively stamped, sorted into divisions corresponding with the principal lines of road, taxed, (or marked with postage, after the necessary examination,)[2] and subdivided for post towns. The amount charged on each postmaster is then told, and entered in his bill, and duplicate preserved. From thirty-five to fifty-five persons are employed in sorting, twenty in taxing, and as many in telling up. The newspapers are sorted by the letter-carriers in their own office: from 120 to 300 being thus employed on different days. Six or more are occupied in examining newspapers, to detect private communications, enclosures, &c. From forty to sixty newspapers are charged daily, the postage amounting to L.100 a-week. After all these operations are finished, the bags are to be filled, tied, sealed, and delivered to the guards. The daily average of letters dispatched from London is 36,000. On Mondays the number is from 40,000 to 50,000. The number of newspapers dispatched from London in the last three months of 1835, was 3,146,127; of 1837, 5,020,230; the one period being previous, the other subsequent, to the reduction of the stamp duty. On Saturdays and Mondays, when the numbers are greatest, (sometimes exceeding 100,000,) it is necessary to engage one or two outside seats on the coaches for their conveyance. Sometimes they are sent separately by the stage-coaches. About 3000 are sent by the Edinburgh mail. The weight of the Edinburgh mail, as ascertained by one evening's trial, was as follows: sacks and bags, 1 cwt. 9 lb. 8 oz.; 2296 newspapers, 2 cwt. 2 qrs. 3 lb. 8 oz.; two stamp parcels, 1 qr. 12 lb.; 484 franks, 1 qr. 19 lb. 15 oz.; 1555 chargeable letters, 1 qr. 6 lb. 14 oz.; in all, 4 cwt. 2 qrs. 23 lb. 13 oz. The weight of the Holyhead mail on the 30th June 1838, was: bags, 1 cwt. 10 lbs.; letters, 1 cwt. 2 qrs. 17 lbs.; Newspapers, 15 cwt. 1 qr. 18 lbs.

In the morning, on the arrival of the mails, the bags are counted and inspected, to ascertain that all have arrived, and with the seals secure; after which they are emptied, and turned inside out, and the amount of the postage marked on the paid letters compared with the account sent by the postmaster. The letters then undergo an examination, in order to its being seen that all have been rightly charged, as single, double, &c. Being then stamped, they are distributed into several larger divisions, as those for the twopenny post, for the window-men, and for the different districts of the town; which last divisions are again subdivided for the walks of individual letter-carriers. Each of the different persons to be engaged in the delivery is then required to tell the amount of postage on that portion of the letters committed to him; and on his reporting an amount corresponding with that brought out by a separate telling previously made, but not communicated, the charge becomes established, and is signed by the party. In case of difference, reference is made to a third person. Each man's letters being then arranged, the delivery commences. The letter-carriers having the more distant walks, are conveyed to the ground by omnibuses, (of which ten are employed for this purpose,) each man being dropped at the commencement of his walk. In the morning duties, there are fifteen persons employed in opening the bags, and checking the accounts; nine in examining letters; fifty sorters; and ten tellers. The number of letters arriving in London daily, is from 30,000 to 40,000.

There is a separate department for dispatch and receipt of foreign mails, and another for the same duties in regard to ship-letter mails. Masters of vessels are allowed 2d. for each letter brought from, or carried abroad.

The number of letters from France in the year 1837, was from 30,000 to 36,000, and about half as many more in transit, through France. Letters expedited to France, from 33,000 to 39,000; in transit through France, from 11,000 to 15,000. Newspapers sent to the continent of Europe, about 30,000 per month; received, about 20,000.

The London penny, or twopenny post, was first set on foot by a person named Murray, an upholsterer, about the year 1683, and by him assigned to one Dockwra. A suit, how-

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[1] Foreign mails arriving after the general post delivery, are delivered by the twopenny post letter-carriers.

[2] Stamping is performed at the rate of from 100 to 200 letters in a minute; examining and taxing, 33; and sorting, 30.

Business and establishments.

ever, was commenced against the latter by Government, and the management of this post withdrawn from him. But he received an indemnification, and was afterwards appointed controller of the office. The present limits of the twopenny and threepenny posts were fixed in 1831.

A *penny* or *twopenny* post-office delivers and collects the correspondence of a particular *portion* of the district belonging to any principal office. In the former respect, (however the duties may be farther subdivided,) it just performs the part of one letter-carrier, with merely the difference of the additional charge on the letters. All letters arriving by the general post at London, for parties residing beyond a circle of three, and within a circle of twelve miles, are transferred to the twopenny post department for delivery; and letters posted for dispatch within the same space, are collected by this department, and transferred to the general post. Such letters are charged 2d. in addition to the general post rates. So far the London twopenny post performs exactly the same functions as any of the penny posts in other parts of the kingdom. It differs from them in so far as it collects and delivers *all* the *local* correspondence, not merely in its own *portion* of the district annexed to the principal office, but in the whole of that district: having its own receiving houses, and its own letter-carriers, within, as well as beyond, the circle of general post delivery. Letters both posted and delivered within the three-mile circle, are charged with a postage of twopence; those crossing beyond it into the space within the wider circle, or *vice versa;* also those both posted and delivered between the inner and outer circles, threepence. The twopenny post subdivides its duties within the three-mile circle, among four branch offices, besides the chief office of the department. The correspondence to and from these, as well as to and from the district beyond the three-mile circle, is conveyed by horse posts, or mail carts. The rides to the country are ten in number, some dividing into two branches, besides four cross rides. There are 209 twopenny post receiving houses[1] within the three-mile circle, and 194 in the country, and 640 letter-carriers and assistants, of whom 270 are employed within the smaller circle. Seven collections and deliveries take place daily within the three-mile circle, and from two to six between it and the outer one. The whole of the twopenny and threepenny post letters, wheresoever collected, are carried to the chief office, and reissued from thence, with exception only of those passing between receiving houses lying in the line of one ride.

The whole number of persons employed on the London general and twopenny post establishment in 1835, was 1338. This includes the country surveyors, 7, and mail guards, 228. In the same year there were 258 persons on the Dublin, and 97 on the Edinburgh establishment.[2] But there has been some increase since.

The number of post-offices is constantly varying. At present they may be stated about as follows: England 649; Scotland 211; Ireland 328: Sub-offices[3] in the three kingdoms, respectively 191—105—102: Penny posts 1085—225—197. *Convention* or *fifth clause* posts in England 50. There are 42 offices in the interior of Jamaica, and 337 in British North America.

There are in England, Scotland, and Ireland, 194 mail coaches and other carriages; 217 saddle-horse posts; 374 mail carts, and 806 foot posts.

The following are the numbers of letters and newspapers posted at all the offices throughout the United Kingdom, in the week commencing 15th January 1838:

Business and establishments.

General post letters, paid,	164,719
..... unpaid,	776,543
Penny post, ... paid,	16,998
..... unpaid,	123,773
Privileged,	122,901
Total,	1,204,935
Of which	
For England,	916,815
... Scotland,	128,584
... Ireland,	159,536
	1,204,935
Total newspapers,	842,646

London twopenny post, (not included above,) total letters, 231,900; newspapers, 10,724.

In the week commencing 29th January, the total number was (including the London twopenny post) 1,550,620,—the postage amounting to L.45,509: Newspapers 858,927. In the week commencing 5th March, the proportion of the classes of general post letters was, (in the united kingdom), single, 699,182; double, 38,562; treble, 11,358; ounce, 1,908; above an ounce, 2447.

The number of charged newspapers returned to the dead-letter office in London in 1837, was above 19,000. The number of undelivered letters, opened and returned to the writers, are about 20,000 in a month.

The total number of ship-letters (*i. e.* letters by *private* ship, not post-office packets,) both sent and received through all the posts in the kingdom was,

For the year ending 5th January 1834,	1,044,000
..... 1838,	1,547,000

The two principal ship-letter ports are Liverpool and Hull; the former being the great channel (by the weekly packets) to America; the latter (by the steam-boats to Hamburgh twice a-week,) to Germany and the north of Europe. The number of letters sent by these, was,

	Liverpool.	Hull.
For the year ending 5th January 1834,	15,318	15,797
..... 1838,	63,116	47,457

The regular mail packets for the conveyance of foreign and colonial correspondence are as follows:—

To France, every day except Sunday, by Dover and Calais, (steam). To Belgium, by Dover and Ostend, four times a-week, (steam). To Hamburgh from London, twice a-week, and to Holland by London and Rotterdam, twice a-week. (These two mails are conveyed by contract in private steam-vessels.)

From Falmouth, to Lisbon, Cadiz, and Gibraltar, once a-week, (steam). From Gibraltar to Malta, Greece, and Ionian Islands, once a-fortnight, and from Malta to Egypt and India, every four weeks, (steam).

To Jamaica, St. Domingo, and Leeward Islands, once a-fortnight, carrying letters to La Guayra one fortnight, to Carthagena the other. To Mexico and Cuba, monthly.

To Halifax, North America, monthly. To Madeira, Brazil, and Buenos Ayres, monthly.

The mails are conveyed between the West India islands by steam-boats, on contract.

On the Falmouth station, there are thirty vessels employed in the packet service, six at the Dover station, and eight steam vessels from the Thames.

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[1] A consolidation of the general and twopenny post receiving-houses, within the three-mile circle, is understood to be now resolved upon.

[2] *Parliamentary Paper*, No. 442. About ninety years before this period, (the Earl of Leicester and Sir John Eyles being postmasters-general) the London *general* post establishment consisted of 157 persons. About the same time the Edinburgh establishment (Sir John Inglis being deputy postmaster-general) consisted of eleven persons, including three letter-carriers, and an officer designated "apprehender of private letter-carriers." (*Present State of Great Britain*, by Mr. Bolton, 1745.)

[3] Sub-offices differ from penny posts merely in having their letters charged according to *distance only*, as in principal offices. *Fifth clause* posts, (so called from the clause of the act 41st Geo. III., under which they are established,) are posts to villages, the inhabitants of which become bound for any deficiency in the expense of maintaining them.

Business and establishments.

For communication between Britain and Ireland, there are packets from Liverpool and Holyhead to Kingston, from Milford to Waterford, and from Port-Patrick to Donaghadee. There are also packets from Weymouth to Guernsey and Jersey, Liverpool to Isle of Man, Aberdeen to Shetland, &c.

Until about fifteen years ago, the post-office had the whole charge of procuring, fitting out, and maintaining the different mail packets. About that time the Falmouth packets were transferred to the Admiralty. A further transfer of most or all of the others was recommended by different commissions appointed to inquire into the management of the post-office, and carried into effect last year, (1837). The grounds of this recommendation were, that the duties required for the efficient and economical management of the packets, were such as the peculiar habits and qualifications of the heads of a civil department did not adequately fit them to perform. A great saving has accordingly been effected by the change of management. The packet communication with France is regulated by treaty made in 1833; and that with Belgium by a similar treaty made the following year.[1] France maintains her own packets for carriage of the French mails to Dover; but receives from L.10,000 to L.12,000 annually from Britain for transit postage of letters carried through her dominions to Italy, Turkey, Switzerland, Spain, &c., according to a scale fixed by the treaties of 1802 and 1836. Out of this, however, she has to pay to Austria the transit duty of letters passing through that country. Hamburgh and Holland pay nothing for having their correspondence conveyed by British packets, but charge no transit. Belgium also charges no transit against Britain, and moreover pays L.1000 yearly for packet conveyance, there being four weekly mails to that country, and only two to Hamburgh and Holland. From L.200 to L.300 a-year is paid by Rio Janeiro.

The mode in which letters are circulated, and the post revenues collected, is as follows:—Each of the three capitals, London, Edinburgh, and Dublin, sends a bag direct to, and receives one direct from, every office in its respective division of the kingdom. Every postmaster sends a bag to every office on the different lines of road leading from his own, as far as the first office (inclusive), at which the mail conveyance makes a stop. Into the bag for the most distant office, are put all the letters (tied up together indiscriminately) that are for places beyond it; and which, accordingly, are here sorted into the bags for each place, as far as that, inclusive, where the next stop takes place, and where the same process is repeated. Letters thus sent to another office to be sorted and forwarded are called *forward* letters. Such as are to go off at a cross line, are sent, as forward, to the office from which the cross line diverges. This is the general principle of the circulation. The moving post-office on the railway answers all the purpose that a sorting office interposed between every two stations on the line would do, at the same time saving the necessity of stoppage. Every office conveys its letters, as *forward*, into the moving one as it passes. In it, the mails for the station next occurring are immediately made up, ready against arrival there: the letters going to stations beyond being separated, so to speak, as forward on the *position* of the moving office, after passing that station. Letters are *taxed* (or marked with postage) as well as stamped, at the office where they are put in; and with every bag is sent a bill containing simply two *items*, namely, the amount of postage for letters in the bag, chargeable on the *sending* postmaster for *paid*, and on the *receiving*, for unpaid. The bill consequently does *not* include the *paid* postage on letters from offices *behind* the sending postmaster's, nor on *unpaid* letters going *beyond* the receiving postmaster's: the former having been already charged, the latter afterwards to be charged on other offices. Thus the postage on every letter whatever, paid or unpaid, is brought to the charge of one office or another. Both the items of every bill are entered in an account at each of the two offices to which its contents relate; the one account checking the other, and the bill remaining to settle differences if any; and when the accounts are summed, the charge against each postmaster is just his *sent paid*, and *received unpaid*. This charge he liquidates either by actual remittances, by allowances to his credit for his own salary and other payments, and by his dead-letter account. The last is vouched, first, by dead-letters actually returned; secondly, by receipts for overcharges; and thirdly, by claims for letters *re-sent* to other offices; which claims, as noted on a form prepared for that purpose and transmitted along with the re-sent letter, are certified by the receiving postmaster; and being forwarded to the inspector of dead-letters, serve to check the claimant's account.

Rates.

The country postmasters' remittances are made to the secretary, who transfers them over to the receiver-general, after furnishing a note of the amount to the accountant, who from thence credits the postmaster, and debits the receiver-general. The revenue collected at the general post-office is paid direct into the hands of the receiver-general by the persons actually collecting, who are merely the window clerks and the letter-carriers; the charge against each, certified by the parties as admitted, being furnished at once to the receiver-general and the accountant by the superintending officer. No account of the *paid* letters is sent from the general to the country offices; the check being there maintained between one department and another. Postmasters advancing the charge on a letter observed to be under-taxed, are required to put their initials to the alteration, which, if the letter is for their own delivery, is in effect sending out a receipt for the additional charge.

The deputy postmasters-general in the colonies are charged with the amount of letters sent them by each mail, in the same way as the country postmasters within the kingdom; the method of check and account between the internal colonial offices being also the same as between the different country offices at home.

The present rates of inland postage in the United Kingdom are as follows:— Rates.

	Britain.	Ireland, (for same distance in *Irish* miles.)
	d.	*d.* *d.*
For any distance not exceeding 8 miles,	2	0 2 and 3
Above 8, not exceeding 15 ...	4	0 0 ... 3
... 15, ... 20 ...	5	0 0 ... 4
... 20, ... 30 ...	6	0 4 and 5
... 30, ... 50 ...	7	5 6 and 7
... 50, ... 80 ...	8	7 8 and 9
... 80, ... 120 ...	9	0 9 and 10
... 120, ... 170 ...	10	0 11 and 12
... 170, ... 230 ...	11	0 12 and 13
... 230, ... 300 ...	12	0 13 and 14

And for every 100 miles above 300, (or fractional part of that distance,) one penny additional.

If the *amount* of all the rates in this scale is taken, and divided by the *number* of rates, it will yield an average of 9d. A similar process applied to the scale of 1710, gives $3\frac{1}{2}$d. for the average. The increase in the intermediate period has been almost gradual, though the intervals between the alterations have been very different. There was no alteration from 1710 to 1765. Since that time, either in the British or Irish, there have been ten alterations. In 1800 the average was $5\frac{1}{2}$d.; in 1810, $7\frac{1}{2}$d.

The sea rates from Port-Patrick, Holyhead, or Milford

[1] *Sixth Report of Commissioners of Post-Office Inquiry.*

Exemptions.

Haven, and Liverpool, to Ireland, are respectively 4d., 2d., and 8d.; from Weymouth to Guernsey and Jersey, 3d.; and from Liverpool to the Isle of Man, 6d.

The packet postage from *London* to France is 10d.; to Switzerland, 1s. 2d.; Holland and Belgium, and Germany, *via* France, 1s. 4d.; Germany and north of Europe, (by Hamburgh,) 1s. 8d.; Spain, Italy, and Turkey, *via* France, 1s. 7d.; Spain, *via* Cadiz, 2s. 2d.: to which is to be added the inland rate to London, *less* 2*d.*, from any office in the country, where a letter may be posted. From *Falmouth* to Portugal is 1s. 7d.; Madeira, Azores, and Canaries, 1s. 8d.; Brazils, 2s. 7d.; West Indies and North America, 1s. 3d.; and inland postage to Falmouth, *less* 1*d.*; to Buenos Ayres, Chili, Peru, 2s. 5d.; St. Domingo, 1s. 3d.; Carthagena, La Guayra, Mexico, Honduras, Cuba, 2s. 1d.; and the full inland postage to Falmouth. To Gibraltar, Malta, Ionian Islands, Greece, Egypt, and India, (by steam from Falmouth,) a uniform rate of 2s. 6d. from all parts of the kingdom. To Cape of Good Hope, East Indies, New South Wales, and Van Diemen's Land, 2d. more than the inland postage.

Letters *from* India, Van Diemen's Land, Cape of Good Hope, &c., 4d. *a letter* above the inland postage; from other parts of the world by private ship, 8d. a *single* letter, and in proportion for double, &c. The charge on ship-letters *outwards*, has been already noticed.

All letters to places abroad must be paid at posting, except packet letters for the British colonies in America and the West Indies, or for France. Failing of this, the letters are opened at the dead-letter office, and returned to the writers.

Letters to and from soldiers and seamen in the service, pass through the whole British dominions for a postage of one penny, payable in advance.[1]

Letters under an ounce weight are charged single, double, or triple, according to the number of pieces of which they consist; triple being the highest rate below that weight. An ounce is charged four single postages, and every additional quarter of an ounce, a single postage more.

Exemptions.

Certain public officers, nearly a hundred in number, have the privilege of franking without any limitation either as to weight or number of letters. Every member of parliament can send ten and receive fifteen letters a-day, free; each letter not exceeding one ounce in weight, and being to and from a place within the United Kingdom. On occasion of passing the bill for the regulation of the post-office in 1657, "a proviso was tendered for freeing members of parliament and other officers of state from payment of any money for letters, which was laid aside without a question."[2] Freedom from postage, however, was claimed by the House of Commons in 1660, but the claim was afterwards dropped on an assurance from the crown that the privilege would be allowed. Accordingly, a warrant was always issued to the postmaster-general directing the allowance to the extent of two ounces in weight.[3] The privilege, however, was abused to an enormous extent, so much so that the servants of members sometimes procured a number of franks for the purpose of selling them. Occasionally, too, considerable frauds were practised by writing promissory notes or other instruments over the signature of a member given on a blank cover. Many curious devices were used by members in writing their signature to prevent this.[4] The estimated postage of franked letters in 1715 was L.23,600; in 1763 it had risen to L.170,700. Until that period, a letter passed free simply by the signature of a member. Even the requirement made by the act passed in 1763,[5] that the whole superscription should be in the member's hand-writing, was found an insufficient check to the abuse; and it was further required by the statute of 1784,[6] that the direction should bear the name of the post-town, and the day, (written in words at length) month, and year of posting. Letters can be franked from any post-town which the member has been within twenty miles of, on the day of, or day before date. They cannot be delivered but for full postage at a place where the member himself is not, (as to any agent or relation,) unless at his residence in London, or his proper house of parliament. Printed votes and proceedings in parliament pass free under certain regulations to and from members of parliament and some public officers. Petitions to parliament, not exceeding six ounces in weight, may be sent free to any member in covers open at the ends.

Exemptions.

Revenue.

In 1653, the post-office revenue was farmed for L.10,000; in 1663 it yielded L.21,500; in 1685, when made over to James II. as part of his private income, it was estimated at L.65,000. The average of the nett revenue, during the eight years of King William's wars, is stated[7] at L.67,222; during four years of subsequent peace, at L.82,319; the average of the years 1707—10, at L.58,052; of 1711—14, at L.90,223. The gross in 1711,[8] was L.111,426. In 1722 the gross was L.201,804, nett L.98,010. From that period till after the middle of the century, the revenue, though of course, subject to occasional fluctuations, made on the whole but little advance, since we find that of the year 1754 to be only, gross, L.210,663, nett, L.97,365. Its progress for the remainder of the century, taken at intervals of ten years, (each ending 5th April), may be seen as follows:[9]

	Gross.	Nett.	Rate per cent. of Collection.
1764,	L.242,566	116,128	52
1774,	334,829	164,077	51
1784,	452,404	196,514	56
1794,	915,608	431,981	40
1800,	1,083,950	720,981	30

From the beginning of the present century the revenue continued increasing progressively until the year ending the 5th January 1816; the following year it was considerably lower, and never rose to such an amount again, until the corresponding year 1837, when it reached its highest. The following table exhibits the particulars; (the Marlborough grants, &c. are not included in the charges of collection.)

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[1] There are other descriptions of special, and modifications of general rates, which would require too much space to particularize. The system of rates is full of the most preposterous niceties and anomalies. It is but fair to state, however, that some attempts have lately been made to introduce greater uniformity, as in the ship-letter and Mediterranean rates.

[2] *Journals*, 9th June. [3] Blackstone. [4] See *Gentleman's Magazine*, 1784, vol. liv.; also vol. xxvii. p. 593.

[5] 4 Geo. III. c. 24. [6] 24 Geo. III. c. 37.

[7] Chambers's *Historical View of the Domestic Economy of Britain.* The *gross*, on a medium of three years prior to 1698, is stated by D'Avenant at L.90,440.

[8] The revenue, as stated for the years previous to 1711, are believed to include the *Irish*. From that year to the end of the century, the account given relates to the *British* revenue solely; the Irish, for this period, not being stated in any of the documents from which the account is taken. In comparing different accounts of the post-office revenue, even including those found in parliamentary documents, the most puzzling discrepancies are to be met with. These, however, are not so much, if at all, to be ascribed to error, as to differences, not expressed in the subjects of the statements. Sometimes the Irish, or twopenny post revenue is included, sometimes not; the revenue for a year, ending 5th April or 5th January, is sometimes given as the revenue for that, sometimes for the preceding year; the *nett* sometimes means the remainder after deducting from the gross the simple charges of management, sometimes after farther deduction of returns, parliamentary grants, &c.

[9] *Second Report of Postage Com. Ap.* p. 176. The nett is after deduction of returns. In 1782, the expense of collection was 72 per cent.

Revenue.

General and Twopenny Post of United Kingdom.[1]

Revenue.

	Year ended	Gross.	Charges of collection.	Returns.	Nett.	Rate per cent. of collection.
		£	£	£	£	£ s. d.
	5th Jan. 1804	1,429,429	416,767	56,450	956,212	29 3 1½
	„ 1816	2,418,741	704,639	94,906	1,619,196	29 2 7¾
	„ 1837	2,461,806	704,768	111,203	1,645,835	28 12 6¾
Greatest *in the interval from* 1816-37.....	„ 1827	2,392,271	706,640	95,869	1,589,762	29 10 9¼
Smallest.....	„ 1822	2,122,965	645,241	84,259	1,393,465	30 7 10½
Greatest (absolute) amount of *charges of collection* from 1816-37..	„ 1827	stated above.				
Smallest ditto.....	„ 1820	2,191,562	586,193	82,729	1,522,640	26 14 11½
Greatest *returns*.....	„ 1835	2,319,979	696,387	110,540	1,513,052	30 0 4
Smallest ditto.....	„ 1823	2,128,926	620,977	79,597	1,428,352	29 3 4½
Greatest *nett*.....	„ 1826	2,367,567	636,353	98,947	1,632,267	26 17 6½
Smallest ditto.....	„ 1822	stated above.				

The *gross Irish general* post revenue for the *year ending 5th January* 1800, was L.84,040; it increased progressing until 1816 when it reached L.225,000; it never attained so high again until 1829, from which it continued increasing till 1832, when it reached its highest, viz. L.256,976. In 1837 it was L.255,070. The lowest amount after 1816 was that of 1823, which was L.186,024. The highest *nett* in the whole period was in 1832, viz. L.154,322; the smallest after 1816, was 1821, viz. L.65,017. The highest rate per cent. of collection, January 1800, L.70, 9s. 2d., lowest, 1832, L.32, 11s. 9d.

The gross receipts of the London twopenny post in the year ending January 5, 1804, was L.60,069; 1837, L.120,801; *nett* for the same years, L.35,640 and L.73,334; rate per cent. of collection for the same years, L.40, 13s. 3¾d. and L.39, 5s. 10¼d.

It is related[2] that in the year 1698, Sir Robert Sinclair of Stevenson had a grant from King William of the whole revenue of the post-office of Scotland, together with a pension of L.300 to maintain the post. Even with this allowance, however, the undertaking was considered hazardous and the grant surrendered. At the union, the post-office revenue was farmed for L.1194. The nett revenue, on an average for three years preceding 1711, was estimated at only L.2000; in 1733 it was L.5399; in 1754, L.8927; in 1776, L.31,103. In the year ending 5th January 1801, the revenue was, gross, L.100,652, nett, L.83,755. It increased progressively till the corresponding year 1815, when the gross was L.203,366, nett, L.161,551. In 1822 the gross had sunk to L.179,404, whence again it took a start in the other direction, and in 1837 was L.220,759, nett, L.160,813. The expense of collection in the present century has varied from 14 to 28 per cent.[3]

The amount of postage charged on postmasters in the West Indies and British North America in the year ended 5th January 1838, was L.78,905, of which above L.18,000 was for unpaid letters from Britain. Of the first sum, there was for Canada, L.38,977, for Jamaica, L.18,274.

Laws.

The postmaster-general is not responsible, under any circumstances, for the safety of letters passing through the post-office, nor for the value they may inclose, if lost or stolen. This point was first settled in the case, Lane *v.* the Postmaster-General, in 1699, (reported in Raymond, vol. i. p. 646). Some doubts hanging over the principle of this decision, the point was again tried, before Lord Mansfield, in 1778, (Whitfield *v.* the Postmaster-General, Cowper's Reports, p. 754,) and judgment given for the defenders. The punishment of death for letter stealing was abolished in 1835,[4] and transportation substituted. Forging, or altering a frank is punishable with seven years' transportation. A newspaper with an enclosure, or any writing or marks, is subject to three times the postage of a packet of equal contents: which postage may be recovered from the sender,[5] or the postmaster-general may prosecute as for a misdemeanour. Masters, crews, or passengers of vessels from abroad, failing to deliver their letters at the first post-office, incur heavy fines. Penalties and postage debts not above L.20, are summarily recoverable. Letters once posted become the property of the person addressed, and cannot be again withdrawn. Other laws (those against illicit conveyance being frequently made public) are of less general concernment.

In the year ending October 1834, there were fifteen criminal prosecutions in England for post-office offences, and twelve convictions, some of them capital; and thirty-four prosecutions for penalties, in which the parties submitted.

The whole acts relating to the post-office have been consolidated into five statutes, viz. 1 Victoria, ch. 32—36.

Alleged defects, &c.

The British post-office has generally been allowed to be remarkable for the precision and regularity with which it circulates the correspondence passing through it, and the celerity with which the official business is conducted; and the prevalent opinion has until lately been, that the department, on the whole, has been skilfully and efficiently administered. Instances, however, both of defects and mismanagement, have, within these few years, been somewhat frequently brought forward, and perhaps with a degree of exaggeration answerable to the indifference with which they had in former periods been regarded. As respects, in the first place, the *constitution* of the department, the inexpediency has been maintained of having the supreme direction vested in a single person, generally a nobleman, removeable at every change of government, and who, by his education and habits, cannot be supposed peculiarly fitted to superintend an establishment, possessing fully more of a commercial than of a civil, or even fiscal character. The tendency, and even the actual effect of such a system has been alleged

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[1] *Appendix to First Report of Postage Committee*, 1838.
[2] *Old Statistical Account of Scotland*, vol. vi. p. 586.
[3] *Second Report of Postage Committee*, 1838.
[4] 5 and 6 William IV. c. 81.
[5] The postage of all returned letters is recoverable from the *sender*, (1 Vict. c. 34, § 2,) but the law has not hitherto been enforced.

Alleged defects, &c.

to be, that of removing the charge from the really responsible head, and throwing it upon a secondary officer. The abolition of the office of postmaster-general, and the substitution of a permanent board of three or more persons, has accordingly been recommended by successive commissions of inquiry; and a bill for giving effect to such recommendation has been twice sent up from the lower, to the upper house of parliament, but refused a second reading by the latter. As regards the *laws* of the post-office, the grand subject of complaint, and that on which perhaps the mind of the community is more made up than on any other, is the high rate of postage, both generally, and in particular cases, as for shorter distances, circuitous routes,[1] penny postage on general post letters, and the like. That there is a great fault in this respect, is argued from the fact of there being little or no increase on the annual revenue, for more than twenty years; and though this fact, to a certain extent, at least, admits of other explanations, it is undeniable that a large amount of correspondence is conveyed otherwise than by post, merely to avoid the expense of postage; and that the existing laws are insufficient, as would any laws be that could possibly be framed, to check such practice. The complaints against the *administration* of the post-office relate principally to the alleged want of sufficiently frequent and numerous communications on various lines of road, and the consequent delay of correspondence, of which the most important case is the want of day mails and Sunday mails[2] from London, there being at present but one day mail, and that but lately established. Without entering into a consideration of the justice of any of the complaints now enumerated, (the fact of their existence being all that it concerns the present purpose to notice), it may be remarked with regard to the *nature* of the particular class just adverted to, that they frequently resolve into questions between the interests of one portion of the community and those of another; or into similar questions between a portion and the whole; or between an advantage with a corresponding sacrifice, and the loss of such advantage; questions to which the administrators of the post-office, at least, profess and appear to have given full consideration, and, either in regard to what is done or what is contemplated, to have determined with a view to the best.

One cause of complaint of not unfrequent occurrence, namely, that regarding the losses that occur in the post-office, by the abstraction of letters containing value, may be said to have been of late in a great measure obviated by the establishment of a system of *money orders*, to be granted by one office, payable at another, to the amount of L.5, at an expense of from 6d. to 1s. 6d. Larger sums can, in general, be safely transmitted through banks.

Alleged defects, &c.

Within these few years, a plan of singular boldness and ingenuity, and developed with the utmost perspicuity and fairness of intention, has been put forth by Mr. Rowland Hill; a plan which aims at the removal of several of the defects of the present post system, but the practicability of which is matter of much doubt and dispute. The main feature of this plan, as every body knows, consists in a proposal to reduce the postage of all letters under half an ounce weight, to a penny, to be collected by a stamp-duty on the paper of the letter or envelope. The great benefits of such a system as this are obvious, the objections are not less so. These (omitting minor articles) resolve chiefly into this dilemma; either the number of letters would not be sufficiently great to produce the required *gross* amount, or, if it were, they would be unmanageable without an additional expense that would as much diminish the *nett*. On Mr. Hill's part, the necessity of the alternative is denied. As respects the first branch of it, he calculates on as many letters as would be sufficient at once to keep up the revenue, and defray any additional expense, first, from the falling in of all the illicit and most of the franked correspondence; next, from the great number of letters that would be sent by persons who now cannot often, or at all, afford postage, and are restrained by fear or conscience from smuggling; and lastly from the variety of printed bills, lists, advertisements, &c., which may be legally sent otherwise than by post, but for which the post would be preferred at a low expense. On the other branch of the alternative he maintains, that, as regards the matters of receipt, despatch, and delivery, the post-office, by being freed from examining, taxing, and the *whole business of accounts*, would be relieved from a great part of the additional labour that would be imposed upon it by the increased number of letters; and, as to conveyance, that the estimated increase of chargeable letters, would add but by a very small proportion to the *weight* or *bulk* of the mails; the far greater part of which is made up of newspapers, parliamentary documents, and franks.[3]

French post-office.

The French post-office, after the modern system, had its

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[1] Since this was written, it has been announced that postage is in future to be charged only for the distance by the nearest carriage road without regard to the actual distance the letter may be conveyed.

[2] It is, perhaps, superfluous to observe, that the subject of Sunday mails and deliveries, involves considerations of a nature quite distinct from those on which questions, relating to post accommodation usually fall to be determined.

[3] That a system promising so great a reduction in the expense of correspondence, would meet with extensive favour and support, is what might be expected; and, consequently, in estimating the weight of the testimony in its behalf, which such support is calculated to yield, it is necessary to distinguish between a desire for its adoption, and a conviction of its practicability; so that we may not ascribe to the latter, what may be wholly due to the former. It is to be remembered, too, that what is called the *practicability* of the scheme, is a very vague expression. In the strictest sense, it must mean practicability, consistently with the maintenance of the present revenue from the post-office, or a revenue not materially smaller; in another sense, the practicability of the plan may mean that its adoption would occasion no deficiency, but what could, and ought to be, otherwise provided for. The supporters of the plan differ in the *sort* of practicability which they ascribe to it; but a conviction of its practicability generally, has been expressed by so many individuals and bodies of men, qualified by their knowledge and habits to judge of such a matter, and so little likely to think with indifference of an embarrassment of the public finances, that a strong presumption of the intrinsic merits of Mr. Hill's plan is unavoidable. The subject has been taken up in most of the principal cities of the empire, by constituted bodies, or associations formed for the specific purpose. Regular inquiries have been instituted by the circulation of minute queries, and otherwise, with the view of ascertaining how far the present system is sufficient as a means of accommodation; how far, as a source of revenue, the duties it imposes are liable to be evaded; and what increase of correspondence by post, or decrease of illicit conveyance, might be expected to take place, under such a reduction of postage as Mr. Hill proposes. Numerous petitions from the most influential and respectable quarters have been presented to parliament, in behalf of Mr. Hill's plan. A Committee of the House of Commons, appointed on the 23d of November 1837, to consider, generally, the subject of a reduction of postage, and especially the merits of Mr. Hill's proposal, has, in the course of two sessions, during which it has been sitting, examined a great number of witnesses, officers of the post-office, merchants, literary men, agents of trading companies, and philanthropic associations, clergymen, and others; all descriptions of persons, in short, the most likely to be able to shew the working of the present system, and to estimate the probable effects of the new. The Committee has, at the same time, collected a vast body of statistical evidence relating to the post establishment, in regard to every particular bearing on the subject of the investigation. The results of the inquiry have been communicated in two voluminous reports.

That the present high rates of postage have operated, in one way, to the repression of correspondence altogether, and in another, to the diversion, into illegal channels, of a vast portion of its existing amount,—a portion much more vast than had ever previously been suspected; that in the latter way, they beget a disregard to the law, and produce that deterioration of the moral feelings, which actions requiring concealment, tend to generate; that, in both ways, they embarrass the motions of trade, check the dissemination of knowledge, curb the

French post-office.

origin early in the 17th century. As in Britain, its revenues at first accrued to the postmaster, and were next for a time farmed. In 1791, the French post-office yielded a revenue of 11,000,000 of francs; about thirty years later, the revenue had become nearly double, and in 1836 it amounted to 37,405,516 francs; the number of letters for that year being 78,970,561. The French post establishment is under the direction of a council, consisting of a chief, and two or more members. The French differs from the British office, in charging postage by *weight*, a mode usual throughout the continent. The French office has been remarkable for the facilities it affords to the circulation of printed matter. All sorts of circulars, lists, advertisements, and the like, may first be stamped on payment of five centimes, and then transmitted by post for ten centimes more, in whole about 1½d. British money. The number of such circulars passing through the French post-office is immense. The business of the Parisian office even exceeds that of the London, there being from forty to fifty thousand letters, and 100,000 printed papers of different descriptions, dispatched from the former daily, Sundays not excepted. The French post towns amount in number to about 1460, but the post accommodation is carried to the utmost possible extent, letters being delivered not merely within the towns and villages, but throughout the country generally.[1] The same degree of dispatch in post business has not, however, been attained in France.

United States post-office.

The post-office of the United States is under the charge of the general government. For a long period it was a source of expense, and it is only during the last six or seven years that it has yielded a revenue, which, however, is now rapidly increasing. The following particulars regarding its present state, are from a report of the Postmaster-General of the United States to the President. On the first of July 1837, the post routes were about 141,242 miles in extent, and the annual transportation of the mails upon them was: on horses and in sulkeys 11,999,282 miles; in stages and coaches 18,804,800; and in steam-boats and

[1] The average of each letter is about fivepence. In Britain, it is probably double this, at least. The charges of collection in France are about 50 per cent., in Britain 28 per cent.

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exercise of the social affections, and confine the efforts of philanthropy; that the post-office, in short, is neither fully and effectually available for the purposes which it is the essential object of such an institution to serve, nor able to preserve the monopoly conferred upon it by law, from systematic and extensive violation; these are points which may fairly be considered as settled by the evidence given before the Committee.

The questions involved in the investigation, as far as it relates to the practicability of Mr. Hill's plan, have been partly of fact, partly of calculation, partly of conjecture and estimate. It being incumbent on Mr. Hill's part to make it appear that the increase of the number of letters would counterbalance the decrease on the postage of each, it became necessary to ascertain what is the actual number by which the present annual revenue is created, and annual expense incurred. This is a question of fact; how many letters at any definite reduced rate would produce the same gross revenue, is one of mere calculation; what increased number of letters might be consequent on such reduction, is one of conjecture. Even the first two descriptions of questions, however, have not been so easily determined as their nature would seem to promise. Actual returns beyond the suspicion of incompleteness or incorrectness are, under the circumstances of haste and perplexity, in which such returns can only be made, and the incapacity of some of those who have to make them, hardly to be expected; whilst, from the fluctuations in the amount of correspondence at different periods, a fair season for presenting an average is not easily fixed upon.* Even, however, after an agreement, actual or assumed, has been attained on this point, several of those differences on subjects of calculation (which, viewed in the abstract, might be supposed of impossible occurrence, but in point of fact, are so often found to occur in regard to the admissibility of *data* and the mode of applying them,) have arisen to complicate and embarrass the inquiry.

One cannot help observing that some of the calculations, the correctness of which has been made matter of dispute, refer to rather irrelevant points. Such, for instance, is that regarding the exact cost of the *conveyance* of letters, &c. in Britain. Mr. Hill's calculations on this point, are probably subservient to the single purpose of evincing the justice of a *uniform charge*, which is done by shewing that the cost of mere conveyance, as distinguished from other parts of the charge of postage, is so small, as to make mere distance an immaterial element in the adjustment of the rate. Without examining (and certainly without admitting) the correctness of Mr. Hill's statements on this subject,† it may be held as allowed, on all hands, that whatever considerations may exist, to justify, or even recommend, the regulation of postage according to distance, these considerations may fairly be made to yield to the advantage of *uniformity*, especially at a very low absolute rate. But conveyance being but a *part* of the expense of distributing correspondence,‡ the calculation now alluded to, goes to no farther end.

Equally irrelevant to the main question (except as facilitating a calculation of the increase of expense under the proposed system, if indeed they serve even for that) are all those *analyses* which Mr. Hill makes of the composition of the present post-office expenditure. It is obvious that, throughout the inquiry (so far as it relates merely to a point of *finance*, its sole relation as presently considered) the *nett* revenue now derived from the post-office, must be taken as a *standard*, by which, according as the revenue to be raised by Mr. Hill's system reaches or approximates to it, the merits of that system are to be tested. Consequently, in comparing Mr. Hill's plan with the present, we must take the expenditure of the post-office *as it is*, unless so far as a saving can be shewn to arise *specifically out of Mr. Hill's plan*. If any deduction, *otherwise*, is made from the charges of management, as applied to Mr. Hill's plan, the same deduction must be made from the present expenditure, thereby raising the *present nett*—that is, raising the standard that Mr. Hill is bound to reach, just in the same proportion that it raises his means of reaching it.§

The real question as to the increase of letters that would be necessary on Mr. Hill's plan, lies in the smallest possible compass. The *gross* revenue to be raised in a given year, after deducting L.71,755, arising from extraneous sources, supposed available under Mr. Hill's plan as well as the present, is L.2,390,515, or 573,723,600 pence. This revenue is at present raised.‖ (taking Mr. Hill's own calculation) from fifty-seven millions of *general* post letters, eight millions of penny post letters, and thirteen millions of *twopenny* and *threepenny* post letters. On the *penny* letters, Mr. Hill calculates on no increase; the *twopenny* and *threepenny*, if reduced to a penny, he expects to increase threefold, making these three descriptions of letters amount to forty-seven millions. Forty-seven millions of pence, deducted from the 573,723,600, leave 526,723,600 to be raised from the *general* post letters, which Mr. Hill estimates (taking in the weights above the penny rate) to produce 1¼d. each. It requires 421,378,880 letters at 1½d. to produce this; and to give such a number, the fifty-seven millions (the present number) require to be multiplied by about 7½, that is, to be increased 7½ fold. Now this would only leave the present nett revenue, supposing the *expenses* to remain as at present. But Mr. Hill allows that a *sevenfold* increase of the number of letters would, or might, increase the expense of *internal* distribution by nearly half a million of pounds, (the difference between L.575,384,

* See Sir Edward Lees's evidence, Q. 9413.

† If postage is to be charged according to the actual cost of conveyance, as compared with the returns, then a letter for ten miles will often cost more than one for 100; if on an average of such cost as applied to the whole, then, of course, the postage will be uniform; but if the charge is to be fixed on the general principle, that the cost of establishing and maintaining a conveyance for a large distance, must exceed that for a small; and that conveyance for a large distance is worth a greater price to the *payer*, inasmuch, as generally it would increase the difficulty to him of getting his letter conveyed, (which seems the *actual* principle of the charge) then distance must be reckoned a fair element.

‡ In this particular, and otherwise, Mr. Hill's statements have been applied (though apparently not intended by him to serve such) to purposes of utter delusion and misrepresentation.

§ These considerations are not brought forward *as if in opposition to Mr. Hill*, (by whom, in his latter statement presented to the Committee, they are given full effect to, though apparently overlooked in his pamphlet) but in order that persons who desire to see the matter with their own eyes, may not be deterred by the apprehension of having to encounter a tedious or intricate calculation.

‖ This assumption appears incorrect, as supposing the year's revenue to be *wholly* raised from letters *posted in the United Kingdom*, without taking into account the postage of those *arriving* from abroad. And as, on the assumption in question, Mr. Hill multiplies the letters of one week by 53, instead of 52, (the postage of the week being but 1-53d of the year's revenue) a deduction of about a million of letters would fall to be made from his estimate.

United States post-office.

railroad cars 1,793,024. The number of post-offices on the 1st December 1837, was 12,089. The revenue of the department for the preceding year was D.4,137,056 . 59
The expenditure,.....3,380,847 . 75

Excess of revenue.....D.756,208 . 84

The average number of dead letters annually, is about 900,000. The number of letters delivered in the year, is estimated at 29,360,992. Free and dead letters about three millions more. The number of newspapers, pamphlets, &c. paying postage, is estimated at about 25 millions. Dead and free newspapers, four millions more.

United States post-office.

The Americans charge in the same mode as the British, namely, by the pieces of which the letter consists. The rates are as follows: for a distance not exceeding

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the present, and 1,035,833 the *prospective* expense.) To balance this, he has the estimated additional rate on foreign and ship letters L.200,000,* (supposing a way shewn of raising this) thus leaving, after an increase of 7½-fold, a *deficit* of L.300,000.

Let the fairness of this calculation be tested, and then let it be reviewed in comparison with that by which Mr. Hill brings out a quite different result, that is to say, nearly *as favourable* a result from an increase of five-fold as has now been done from 7½.

After having on grounds, the correctness of which have been in part already questioned, (and, for the rest, are neither admitted nor denied), raised the number of letters for a year, from seventy-four to seventy-eight millions; he next, on a ground which, on a moment's reflection he would probably give up as untenable,† raises them to eighty millions. These, at 1¼d. each, would produce L.416,666. Increased five-fold, they yield L.2,083,330, The cost on inland distribution he makes L.868,967, which, together with L.112,162, (other branches of expenditure) makes L.981,129. This deducted from the gross, leaves L.1,102,201 for the nett; to which he adds the two items just mentioned of L.196,000 and L.48,000, thus making the total nett L.1,346,201, or only something more than L.300,000 of a deficit on a *five*-fold increase. Now all that is necessary for the purpose of explaining how this more favourable result is brought out, is to compare the produce of his *five*-fold, with that of his *one*-fold. The former will be found just five times the amount of the latter; and as the *one*-fold includes all descriptions of letters, penny, twopenny, and threepenny, five times the produce of the one-fold, of course, suppose an equal increase on all.‡

Finding the average postage of a letter is merely another method of arriving at the same result. The average postage of a *general* post letter, appears from the returns to be above 10d. An eight-fold increase (at 1¼d. on average for each letter) would therefore produce the same amount on the present number at 10d. Other two-folds of an increase would produce L.475,000, to which the L.200,000 for foreign and ship letters being added, there would be L.675,000 for additional expenses. While it is admitted then to be a *vague* statement, (vague as respects the estimate of the increased expense, which can only be a guess), it is believed to be a *moderate* one, to say, that on ten-fold increase of general post letters, with a three-fold increase on the *twopenny* and *threepenny* post letters, would be necessary to uphold the present revenue.§

This, indeed, is a calculation, both the *data* and the conclusions of which, any plain man who pays twenty shillings to the post-office in a twelvemonth, may verify on five minutes' reflection. Let such a one consider, whether the average of his *general* post letters can be less than 10d., and then say, if the average cost were reduced to 1¼d., whether it could require less than ten letters for one, taking into consideration the increase of expense, to uphold the present revenue?

Passing now from matters of calculation, to those of conjecture and estimate, we encounter, as may be supposed, a much wider diversity of opinions. This head embraces that most essential question,—what precise increase of correspondence might be expected under such a reduction as recommended by Mr. Hill. That an increase would take place which, absolutely speaking, may be characterized as immense, may be held as at all hands acknowledged; but in specifying the probable rate of such increase, in relation to that which would be necessary for the safety of the revenue, there is every possible variety of estimate,‖ ranging from, "very considerable" up to "beyond calculation," from four to a hundred fold; of which extremes the *medium* may be given as "ten-fold," or "increase that would keep up the revenue." It is obvious, however, that evidence of this nature requires to be received with some degree of deduction. Besides being mostly *conjectural*, it may be said to be all *ex-parte*, brought forward *in support* of the scheme, the eligibility of which was the subject of investigation. There is no opposing party. Government is constrained, in such an inquiry, to be neutral. To the administrators of the post-office, interference would be an invidious office, seeing that even their evidence is apt to be viewed as that of interested, or at all events, prejudiced persons. The cross-examinations instituted by some of the members of the Committee, would be required even as a counterpoise to the effect of leading questions put (certainly without the slightest appearance of unfair intentions) by the others. When to this is added the significant fact, that few, indeed, of the witnesses ventured to state, that they would pay as much postage under the proposed reduction as at present, (while an increase of outlay is admitted to be inevitable on such reduction) and that the generality only hoped for a surplus revenue equal to the present, after the lapse of a considerable period; when we advert to another important fact, that scarcely one of the witnesses professed to have examined Mr. Hill's calculations, but merely to have *assumed* their correctness; when these considerations are taken into account, it is surely not too much to say, that the adoption of the plan in question would place the post-office revenue in very imminent hazard.

But although Mr. Hill's plan has been perilled by some of his supporters, if not by himself, on this issue, that it would, at least, maintain the present revenue, its proved insufficiency *on this issue*, is not, on a larger view of the question, to be viewed as conclusive against it. Even in a financial point of view, a defalcation in this source of revenue would probably be met by a proportionate growth in others. The increased facilities given to trade, would, in a variety of ways, tend to the creation of revenue. Even the increase on the paper duties might not be an inconsiderable item, though perhaps liable to be balanced by a corresponding decrease on those on advertisements. Viewing the advantage to commerce, literature, and morality, which would arise from a cheap system of postage, there are probably few persons conversant with subjects of social or political economy, who would advocate the employment of the post-office as a source of revenue, on any other grounds than, in the present circumstances of this country, the difficulty of finding another as a substitute.¶

Put off the supposition, however, that such an increase of correspondence would ensue, as that which has been mentioned as the average

* Mr. Hill also claims, as a receipt to fall into him, L.48,000 for "payments by government offices not entitled to frank." But, it is presumed, the letters for which these payments were made on the year taken, were part of the 78,000,000; and, if so, query, farther, whether these ought not to be deducted from the number of increasable letters? The government officers would send no more letters at a penny than they do at present. In the uncertainty, however, as to the grounds of this claim, let it be allowed; still the deficiency, after so great an increase, will remain a quarter of a million.

† The ground is, the high postage of ship and foreign letters which *came in* the week of the *return*, Q. 11032. But letters *arriving from abroad*, formed no part of the return, nor could their postage affect the question. It is but fair to say, however, that the suggestion on this point did not come originally from Mr. Hill.

‡ Is not this multiplying the penny letters in the same *ratio* with the others, as objected to by Lord Litchfield? It is true, that with the explanation that Mr. Hill would give it, namely, that by a *fivefold* increase, *he means* the average of a sixfold on the general post, and a threefold on the twopenny and threepenny, (the penny remaining the same); this would be merely a different mode of expressing the same thing. Practically, it is a deception; because, any *increase* promised by Mr. Hill, being an increase *by virtue of reduced postage*, whenever he says that a fivefold increase would produce such and such a revenue, every body will understand him to mean, a fivefold increase of *reducible letters*, that is, (mainly) of *general post* letters. If Mr. Hill owns, as he would own that his statement, *in this meaning*, would be untrue, how can he complain of Lord Litchfield for supposing what would be necessary to make it true; namely, a fivefold multiplication of the *penny* letters, as well as of the others? In *substance*, then, there is an agreement as to the principle of the calculation; a difference as to the *data*—the number of letters from which a given revenue is *at present* drawn.

§ The average postage of a letter has been represented to be 6½d; consequently, it is meant to be inferred, a sixfold increase, or little more, would produce the present revenue. But if this is the average *at all*, is it the average otherwise than by including the penny and twopenny letters? or would *these* increase sixfold? Do not the more unscrupulous supporters of Mr. Hill's plan, who blazon abroad partial statements of the kind, see that they prove too much? If 6½d. is the average of *increasable*, that is, of general post letters, (the sense intended to be conveyed) what becomes of the outcry about the exorbitant rate of postage? Tell a man, that for 6½d., at an average, he may have a letter conveyed, with the utmost possible speed, and with all but infallible certainty, to any part of the known world, and will he sympathise in the complaint of excessive charge? Mr. Hill's plan may safely be allowed to rest on its merits; let it be allowed to rest there, without the employment of deception and misrepresentation.

‖ The importance of keeping these two points distinct in the mind, is shewn from this, that Lord Ashburton is made, in the Appendix to the Report, to give evidence of the probability of a "great increase," while his Lordship explicitly states his belief, that the adoption of Mr. Hill's plan would be equivalent to a surrender of the whole post-office revenue.

¶ Might such a mode as this be suggested:—Let a bill be brought into Parliament, to grant her Majesty a certain revenue from *postage*, to be raised after the manner described by Mr. Hill; but containing provisions, that any deficiency of such revenue is to be supplied from other *defined* sources. Let these sources be named by the Chancellor of the Exchequer, or offered by the supporters of Mr. Hill's scheme, (to which the latter could not object, as on their principles the provisions would be inoperative for want of occasion;) but, at all events, agreed upon as an essential part of the bill.

Postulate ‖ Potash.

30 miles,	6 cents.
above 30 and not exceeding 80,	10
80 ... 150,	12½
150 ... 400,	18¾
400	25

Ship letters at the port of arrival, 6 cents; 2 cents more than the inland postage, if carried inland. Newspapers 1 cent, or 1½. Magazines and pamphlets from 1½ cent to 6 cents per sheet, according to mode of publication and distance.[1] Potatoes.

POSTULATE, in mathematics, is described to be such an easy and self-evident supposition, that it needs no explication or illustration to render it intelligible.

POTAMON, or POTAMO, was a philosopher of Alexandria. He steered a middle course between the scepticism of the Pyrrhonists and the presumption of the Dogmatists; but attached himself to none of the schools of philosophy of his time. He was the first projector of the Eclectic sect; for though the mode of philosophising had been pretty common before, he was the first who attempted to institute a new sect on this principle. Diogenes Laertius relates, that not long before he wrote his *Lives of the Philosophers*, an Eclectic sect, ἐκλεκτική τις ἄιρεσις, had been introduced by Potamo of Alexandria, who selected tenets from every former sect. He then proceeds to quote a few particulars of his system from his Eclectic Institutes, respecting the principles of reasoning, and certain general topics of philosophical inquiry; but from these nothing further can be learned than that Potamo endeavoured to reconcile the precepts of Plato with those of other masters.

POTASH, the lixivious ashes of certain vegetables, used in making glass, soap, and other articles. See GLASS, SOAP, and CHEMISTRY. Potash was formerly considered as a simple substance; but it appears, from the discoveries of Sir H. Davy, to be a compound of a peculiar metallic substance and oxygen.

POTATOES, of the order *solaneæ*. See BOTANY. It seems to be the prevalent opinion that potatoes were first introduced into Europe from America, by Sir Walter Raleigh, about 1586. Gerard, an old English botanist, mentions that he had reared seedlings of the potatoe in 1590, and that it grew as well in his garden as in its native soil, Virginia. Gerard gave to the potatoe the botanical name of *solanum tuberosum*,—a name adopted by Linnæus, and which it still retains. Previously to 1684, its cultivation in England was confined to the gardens of a few of the nobility and gentry. It was then first planted in the open fields in Lancashire, a county in which it is now very extensively cultivated. In an account of the household expenses of Queen Anne, wife of James I., who died in 1618, and which is supposed to have been compiled in 1613, the price of potatoes is stated at 1s. a pound.

[1] A *cent*, or hundredth part of a dollar, is about a halfpenny.

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of the estimates on this point, the question has arisen, to what extent a corresponding increase of the post establishment must take place, both as regards the *space* in which the duties are to be performed, and the number of persons required for such performances.* The chief difficulty apprehended, is that which would be experienced in the *dispatch* of the mails from London, and other large offices, under the circumstances of the closeness of the hour of receipt to that of dispatch, to which the public are accustomed, and the great proportion of letters that are put in at the very latest hour.† On these points, the officers of the post-office, who can alone, or who can best form an opinion, while they concur in stating that a large additional expense would certainly be incurred, profess not to be able to form, or, in point of fact, not to have formed, any definite idea of its extent. The sums put to this amount in the foregoing calculations, may be considered as stated in mere conjecture; nor is it very easy to offer anything on the subject further than to observe, that any saving of time or labour, in regard to the business of dispatch, effected by Mr. Hill's plan, applies only to the taxing; partly, if at all, to the examination, and to the telling up: the duty occupying the longest time, (that of sorting) together with the stamping, being increased in full proportion to the increase of letters.

Of the minor difficulties attending Mr. Hill's plan, that which regards the mode of collecting the postage on *foreign* letters, is the most considerable. Mr. Hill seems latterly to think, that, as regards these, it might be necessary to take payment on delivery. But it seems, by no means clear, that Mr. Hill's first suggestion on that point, (namely, that of charging twopence in advance outwards, and nothing inwards) is liable to any great objection *peculiar to this part of his plan;* the persons who *send* letters abroad, being generally the same who *receive* from abroad. The inconvenience of having letters above weight, returned (after opening) from the dead letter office, cannot be allowed to stand in the way of an extensive arrangement otherwise beneficial. If parties would neither be at the pains to weigh their letters, *nor use a stamp of a penny higher price*, when in doubt, they might very fairly be left to take the consequence.

But after considering all the defects and difficulties of Mr. Hill's plan, the question recurs, if we do not adopt it, what *else* is to be done? That a *great* reduction of postage must be made, seems to be universally admitted; but what *other* scheme of reduction has been proposed, or who is ready to propose one? If we are to reduce *at all*, there seems much reason to question, whether any reduction short of that proposed by Mr. Hill, will be to good purpose. The Committee have recommended a penny rate for distances not exceeding fifteen miles, and twopence for larger distances. But there are not wanting good grounds for maintaining that the penny rate might fetch a greater revenue than the twopenny one.

Speaking loosely, it may be reckoned that, at a uniform penny postage, a fourfold increase on the general post letters, and a threefold on the twopenny and threepenny, would more than cover the charges of management. That an increase to this extent would ensue, may be held for certain; that it would ensue to double or treble this extent is, if improbable, not beyond the bounds of possibility. So that, at the worst, perhaps, the utmost evil that would arise from the adoption of Mr. Hill's plan, would be the payment of a million and-a-half of taxes in one way, instead of in another, while the vast advantage of a low rate of postage would be so much clear gain obtained. And this leads to a consideration of what, in a question of political economy, ought to be reckoned the *proper measure* of the advantage of Mr. Hill's plan. Suppose a person to pay L.1 a-year in postage, and L.5 in other taxes; suppose that in another year he pays only 5s. for postage, and L.5, 15s. in other taxes, it is evident that, *ceteris paribus*, matters will remain the same, both as regards the state and the individual, that is, if the *number of letters* which the individual gets conveyed *remains the same.* But if, on the latter supposition, he gets twenty-five letters conveyed, while on the former he only got twenty, the conveyance of the five letters additional is a clear advantage gained. The true measure then of the benefits of Mr. Hill's plan, is not the amount of surplus revenue it creates, as relative to the present, but the *number of letters conveyed, on that plan, as relative to the expense of conveyance.* If Mr. Hill, by adding twenty-five *per cent.* to the cost of conveyance, can add 100 per cent. to the number of letters conveyed, this is clear benefit. And as there can be no real advantage from the adoption of his plan that does not resolve into this principle, so (speaking on the abstract) any alleged disadvantage, not resolving into the same principle, may be regarded as only apparent.

* As regards increase of expense for *conveyance*, there does not seem so much ground for apprehension.

† Various suggestions might be offered for lessening this difficulty. For a time, at least, the system of receiving a *fee* with late letters might be extended. This would be no nullification of the boon of a cheap postage; for it would be the fairest and most convenient way of throwing the expense on those who most created it, and who could best find their account in increasing it. Or London might be split down into separate post towns, with separate bags from each, (an inconvenience that would be gradually diminishing, as railways, with *moving* offices, were established.) Or three or four different kinds of stamped covers might be sold, distinguishing by *colour*, and marked respectively, *late, later, latest*, and charged 3d., 6d., or 1s. each, to be received up to certain hours. A clerk, at the receiving box, could, with great quickness, throw out *in transition* all of the *wrong* colour for the *hour*, to wait next dispatch; or, as often as the sorting boxes are filled, their contents might be transferred to the bags.

Potentia ‖ Potosi.

Potatoes were not introduced into Ireland until 1610, when a small parcel was sent by Sir Walter Raleigh to be planted on his estate in the vicinity of Youghall. There is no other instance of the cultivation of an exotic having been so rapidly extended in so short a period as has elapsed since potatoes were introduced into Ireland.

Potatoes were not raised in Scotland, except in gardens, till 1728, when they were planted in the open fields by Thomas Prentice, day-labourer at Kilsyth. Prentice died at Edinburgh so late as 1792.

It has been estimated that one acre of land will produce three times, or at least twice, as much food when growing potatoes, as when employed in the culture of wheat; consequently, where the inhabitants live upon potatoes, the population will be twice or thrice as dense as where they are fed entirely on corn. While, however, the use of the potato as a principal article of food renders population comparatively dense, it tends also to render the people habitually poor, and to multiply the chances of famine. For the cultivation of the potato see AGRICULTURE. For the political views see M'Culloch's *Commercial Dictionary*, and his notes to Smith's *Wealth of Nations*.

POTENTIA, POWER, that whereby a thing is capable either of acting or being acted upon.

POTENTIAL, in the schools, is used to denote and distinguish a kind of qualities which are supposed to exist in the body *in potentia* only; that is, to be capable in some measure of affecting and impressing on us the ideas of such qualities, though not actually inherent in themselves. In this sense we say, potential heat, potential cold, &c.

POTENTIAL, in *Grammar*, an epithet applied to one of the moods of verbs. The potential is the same in form with the subjunctive, and is, according to Ruddiman, implied in that mood, for which reason it is rejected by that grammarian; but others consider that it differs from the subjunctive by always implying in it either *possum*, *volo*, or *debeo*. It is also called the *permissive mood*, because it often implies a permission or concession to do a thing.

POTIPHAR, or PUTIPHAR, an officer of the court of Pharaoh, king of Egypt, and general of his troops, according to our translation, Le Clerc, and the version of the vulgate; but according to the Hebrew and Septuagint, the chief of his butchers or cooks. The Hebrew text, the Septuagint, and vulgate, call him Eunuch. But it is probable it in this place means only an officer of the king's court, for he was certainly married and had children. We have no other account of him but what appears in Scripture.

POTOMAC, a large river of North America, which forms through its whole course the boundary between the states of Maryland and Virginia. It rises in the Alleghany Mountains, and flowing in a north-easterly direction towards Pennsylvania, it forms a junction with the Shenandoah at Harper's Ferry, and then makes its celebrated passage through South Mountain. At its embouchure it is seven miles and a half in breadth; and at Alexandria, 290 miles from the ocean, it is one mile and a quarter in breadth. Tide-water reaches about 300 miles from the Atlantic; and for nearly that distance the Potomac is navigable for the largest vessels. The river is seven fathoms deep at its mouth, five at St George's Island, three at Swan's Point, and thence to Alexandria of the same depth. The length of its course, the curvatures included, is considerably above 300 miles.

POTOSI is the name of a department, a province, and a city of Bolivia, in South America. This part of the republic has been celebrated from the earliest times for its metallic wealth. The Cerro de Potosi, where the argentiferous mines are situated, is a conical hill, 16,037 feet in height, and about three leagues in circumference at the base. It bears marks of a volcanic origin, and its sides are marked with spots of various hues, such as dark green, orange, gray, and red. In this mountain no less than above 5000 mine mouths or levels have been opened, but very few of the mines are now worked. A tradition exists that Diego Hualca, an Indian peasant, accidentally discovered these mines whilst hunting the wild goat. In pursuing his game, he arrived at a steep declivity, and, to prevent himself from falling, he seized hold of a shrub, which, yielding to his weight, was torn from the ground, and disclosed to his eyes a large mass of silver, part of which adhered to the roots of the plant. A slave to whom he intrusted the secret of his good fortune betrayed him, and the mine was opened by the Spaniards on the 21st of April 1545. The surrounding country is also metalliferous. Silver of great fineness abounds in a hill called Guayna-Potosi (Young Potosi), close to the Cerro; but from the number of springs which occur not far from the surface, it has been found impossible to work it. The ore is pulverised in mills, driven by streamlets conducted from lakes or pools in the mountains, from one to ten miles distance from the city of Potosi. In connexion with the mines, General Miller relates the following circumstance. "A singular custom, which probably originated in the indulgence of early mine-owners, still prevails. Between Saturday night and Monday morning, the Cerro literally becomes the property of such persons as choose to work upon their own account. During that time, the boldest master would not venture to visit his own mines. They who thus take possession are called caxchas, and generally sell the produce of Sunday to their own masters. Independently of the ore thus abstracted, the caxchas did considerable mischief, by neglecting the proper precautions as they excavated. If they met with a more than usually rich vein in the course of the week, it was passed over, and cunningly reserved for the following Sunday. Very strong measures were therefore taken to abolish the custom; but every effort proved unsuccessful. The caxchas defended their privilege by force of arms, and by hurling down large stones upon their assailants." These mines are still considered the richest in South America, but great ignorance of mining operations is displayed in working them. In an agricultural point of view this province is unimportant; its riches consist in its mineral wealth.

The city of Potosi, the capital of the department, is situated on the south side of the mountain, above 13,000 feet above the level of the sea, in lat. 19° 34′ south, and long. 67° 22′ west from Greenwich. Upon the discovery of the mines, it was named an *asiento* or mine-station; but in process of time it was raised to the rank of a town, and made the capital of an intendencia. In 1611 it contained 150,000 inhabitants, according to a census taken by order of government officials. On this point General Miller judiciously observes, "This number must at that time have consisted principally of *mitayos* of every tribe existing between Potosi and Cuzco, a distance of nearly 300 leagues. Those unhappy beings were generally accompanied in their labours by their wives and families, who came rather to share in the hopeless sufferings of their husbands and fathers, than to settle in the arid hills of Potosi. It is not therefore surprising that its population should have been, by the abolition of the *mita*, and by the shocks which wealthy establishments received during the revolution, reduced to only 8000 in the year 1825."

Potsdam.

POTSDAM, one of the provinces into which the kingdom of Prussia is divided. It is bounded on the north by the duchies of Mecklenburg-Schwerin and Mecklenburg-Strelitz, on the north-east by Pomerania, on the east by Frankfort, on the south by Saxony, on the south-west by the duchy of Anhalt-Dessau, on the west by Prussian Saxony, and on the north-west by the kingdom of Hanover. It extends over 8272 square miles, and comprehends 67 cities, or places once fortified, 16 market-towns, and 1319 villages, besides scattered houses, and distinct agricultural es-

Potten ‖ Potter.

tablishments. It is divided into thirteen circles. The population, which in 1817 consisted of 696,878 individuals, had increased in 1826 to 812,138, and has gone on augmenting up to the present time. With the exception of about 3000 Catholics, and about 2000 Jews, the whole of the inhabitants profess the Protestant religion. The land is generally level, and though tolerably cultivated, is by no means productive, though there are some local exceptions. It is provided with great natural means of access to the sea by the navigable river Havel, which falls into the Elbe, and which affords a communication between the different portions of the province. The capital of this province is the city of the same name, the first in exterior beauty in the Prussian dominions. It is situated twenty-one miles from Berlin, on an island about eighteen miles in circumference, formed by some lakes and canals, and by the river Nuthe, which here joins the Havel. Potsdam contains seven Protestant and one Catholic church, and a synagogue for the Jews. The inhabitants are about 26,000, the dwellings 1640. The civil population does not exceed 16,000 persons. The others are either military, or those employed in the fabrication of arms. The muskets for the troops are made at Spandau, but are fitted with locks and finished at Potsdam. There are manufactories carried on of silk and cotton, of leather, of cloth, of snuff, of musical and mathematical instruments, and some large breweries and distilleries.

POTTEN, a market-town of Bedfordshire, in the hundred of Biggleswade, forty-nine miles from London. It is well built now, having been burned down in 1785, after which for some time the inhabitants lived under tents. It is in a fertile district, and has a good market on Saturday. The population amounted in 1801 to 1103, in 1811 to 1154, in 1821 to 1498, and in 1831 to 1768.

POTTER, Christopher, a learned English divine, was born in 1591, and bred at Oxford. In 1633, he published his *Answer to a late Popish Plot*, entitled *Charity Mistaken*, which he wrote by special order of Charles I., whose chaplain he was. In 1634, he was promoted to the deanery of Worcester; and, in 1640, was constituted vice-chancellor of the university of Oxford, in the execution of which office he met with some trouble from the members of the Long Parliament. Upon the breaking out of the civil wars, he sent all his plate to the king, declaring that he would rather, like Diogenes, drink in the hollow of his hand, than that his majesty should want; and he afterwards suffered much for the royal cause. In consideration of this he was nominated to the deanery of Durham in 1646, but was prevented from being installed by his death, which happened about two months thereafter.

Potter, John, D.D., Archbishop of Canterbury, was the son of a linen-draper at Wakefield in Yorkshire, where he was born about the year 1674. He studied at University College, Oxford; and at the age of nineteen he published, *Variantes Lectiones et Notæ ad Plutarchi librum ad audiendis poetis; et ad Basilii Magni orationem ad juvenes, quomodo cum fractu legere possint Græcorum libros*, 1693, 8vo. In 1697, came out his edition of *Lycophron*, in folio, which is reckoned the best of that obscure writer; and soon after, he published his antiquities of Greece, in two vols. 8vo. These works established his literary reputation, and engaged him in a correspondence with Grævius and other learned foreigners. In 1706, he was made chaplain to the queen; in 1715, bishop of Oxford; and in 1737, he succeeded Archbishop Wake in the see of Canterbury, which high station he supported with much dignity until his death in 1747. He was a learned and exemplary churchman; but not of an amiable disposition, being too strongly tinctured with the pride of office. Nor is it to his credit that he disinherited his eldest son for marrying below his rank in life. His theological works, containing sermons, charges, discourses on church government, and divinity lectures, were printed at Oxford in 3 vols. 8vo, 1753.

Pottery.

POTTERY and Stone-ware. Under this name may be classed all those wares, from the common butter-pot mentioned by Dr Plot, to the finer kinds of earthen-ware, which, in contradistinction to porcelain, possess neither transparency nor any degree of vitrification, except on the surface after being glazed.

The most famous manufacture for this common ware, as Dr Plot states in his History of Staffordshire (1686), was at Burslem, in that county, now one of the principal towns, forming a part of that extensive and populous district called the Staffordshire potteries, in which it is calculated that no less than 30,000 persons, or one half the population, are directly employed in the manufacture of porcelain and earthen-ware. It is proved, however, that the manufacture of common wares had existed long before Dr Plot's time; but of its first introduction no tradition remains.

These common wares were made of the clays found in the district, and were of a red body covered with a glazing of lead ore, with a portion of manganese added to make a black when that colour was wanted.

About the year 1690, two ingenious artisans from Germany, of the name of Eller, settled near Burslem, and carried on a small trade for a little time. They brought into this country the method of glazing stone-ware, by casting salt into the kiln while it is hot, and some other improvements of less importance; but finding they could not keep their secrets to themselves, they left the place rather in disgust. From this time various kinds of stone-ware, glazed by the fumes of salt in the manner above mentioned, were added to the wares before made. The white kind, which afterwards became, and for many succeeding years continued, the staple branch of pottery, is said to have owed its origin to the following accident. A potter, Mr Astbury, travelling to London, perceived something amiss with one of his horse's eyes; an hostler at Dunstable said he could soon cure him, and for that purpose put a common black flint-stone into the fire. The potter observing it, when taken out, to be of a fine white, immediately conceived the idea of improving his ware by the addition of this material to the whitest clay he could procure. Accordingly he sent home a quantity of flint-stones of that country, where they are plentiful among the chalk, and, by mixing them with tobacco-pipe clay, produced a white stone-ware much superior to any that had been seen before.

Some of the other potters soon discovered the source of this superiority, and did not fail to follow his example. For a long time they pounded the flint-stones in private rooms by manual labour in mortars; but many of the poor workmen suffered severely from the dust of the flint getting into their lungs, and producing dreadful coughs, consumptions, and other pulmonary disorders. These disasters, and the increased demand for the flint-powder, induced them to try to grind it by mills of various constructions; and this method, being found both effectual and safe, has continued in practice ever since. With these improvements, in the beginning of the present century, various articles were produced for tea and coffee equipages. Soon after, attempts were made to furnish the dinner-table also; and before the middle of the century, utensils for the table were manufactured in quantity as well for exportation as home consumption.

But the salt glaze, the only one then in use for this purpose, is in its own nature so imperfect, and the potters, from an injudicious competition among themselves for cheapness rather than excellence, had been so inattentive to elegance of form and neatness of workmanship, that this ware was rejected from the tables of persons of rank; and about the year 1760, a white ware, much more beautiful and better glazed than ours, began to be imported in considerable quantities from France.

Pottery. The inundation of a foreign manufacture, so much superior to any of our own, must have had very bad effects upon the potteries of this kingdom, if a new one, still more to the public taste, had not appeared soon after. In the year 1763, Mr Josiah Wedgwood, who had already introduced several improvements into this art, invented a species of earthen-ware for the table, quite new in its appearance, covered with a rich and brilliant glaze, bearing sudden alternations of heat and cold, manufactured with ease and expedition, and consequently cheap, and having every requisite for the purpose intended. To this new manufacture the queen was pleased to give her name and patronage, commanding it to be called *Queen's ware*, and honouring the inventor by appointing him her majesty's potter.

The common clays of the district are now mostly used for making the saggers or cases in which the finer wares are fired, for bricks to construct the ovens and kilns, and for some kinds of inferior wares, while the clays for the improved article are brought from Devonshire and Dorsetshire by sea to Liverpool, and by the canal to the potteries. The flint-stone is obtained mostly from London, so that it would appear the cheapness of coals has been the principal reason for the establishment of extensive potteries in this inland district, notwithstanding the heavy charges of transport on the raw materials to the seat of manufacture, and, so far as the export trade is concerned, again on the manufactured articles to the shipping ports.

Before the introduction of steam power to machinery purposes, the flint-stones were ground by water-mills at a considerable distance from the manufactories; but many of the manufacturers have now erected steam-engines of great power, for the purposes of grinding flint, and other materials used in the different processes of the manufacture.

The article of *queen's ware*, before mentioned, was composed of the Devonshire and Dorsetshire clays, mixed with a proportion of ground flint, covered with a fine soft glazing, composed of siliceous earths and carbonate or oxide of lead. This glazing, covering a very porous body, made of the above clays and a portion of flint-stone, was liable to crack or craze, and become discoloured in the using, causing a prejudice against it, under an erroneous idea that, by its coming in contact with acids and salts, the glaze had been decomposed, that the lead it contained was poisonous; and a premium was accordingly offered by the Society of Arts for the discovery of a glaze without lead, which was only cancelled on the books of the society a few years ago. It appears singular that it did not immediately occur to scientific men, that all the chemical vessels made of glass contain as large a portion of lead in their composition as there is in the glaze on queen's ware, and that the vitrification is as complete in the one case as the other. The fact is, that, through the cracks in the glazing, it was the earth composing the body of the ware which the acids and salts acted upon, leaving a coloured deposit, visible through the extreme thin lamina of glazing which covers it.

This defect in the glazing arises from several causes; the want of a corresponding contraction of the body and the glaze, from too sudden a cooling of the oven, and other mismanagement of the workmen.

Since the introduction, however, of a better clay from the mines in Cornwall (about 1777), together with a stone containing a notable quantity of feldspar, the potter has been enabled to bring his earthen-ware to a very great degree of perfection; the defect in glazing above noticed has been greatly diminished on the queen's ware, and other glazes introduced, in appearance possessing much of the texture and whiteness of porcelain, though still deficient in the solidity and compactness of the old white stone-ware which it had superseded.

About the year 1805 an article was produced called *Ironstone-ware*, in which, however, not a particle of iron stone was introduced, it being a compound principally of the Cornish materials above mentioned. Pottery.

This ware has nearly all the properties of the Japan porcelain; it possesses great hardness and density; is sonorous, but is deficient in whiteness and transparency, although the vitrification is as complete as in that of the Japan. It continues to be made in great quantities, and being more durable, is perhaps, though higher in price, as economical as earthen-ware. It is a cheap substitute for porcelain, but its nature does not admit of those fine paintings and splendid decorations which are applied with so much success on that more elegant production.

From the common earthen-ware to the finest porcelain, the manipulations are nearly similar. The materials being finely ground and levigated, are mixed together in their proper proportions in a liquid state, and this mixture being put into broad shallow pans or kilns, is subjected to a heat sufficient to evaporate the extra water until the clay is of a proper consistency for use, and it is then prepared by beating with wooden and iron paddles until it becomes one ductile homogeneous mass, fit for the operation of the workman. The operations of throwing on the wheel, turning in the lathe, and moulding, are similar to those already described in the article on porcelain. Manipulation.

The potter's wheel consists of a triangular bench, whereon the workman sits, having before him a small horizontal circular block on which he places the portion of clay made into a ball, according to the size of the piece of ware wanted to be made, and with his hands fashions it into the shape wanted; the inner surface being smoothed by a piece of slate, iron, or earthen-ware, cut to the form required. This workman has two assistants; one employed to prepare the balls of clay, and remove the piece when formed; the other to turn a larger vertical wheel, which gives motion to the horizontal block, or whirler, as it is called, before mentioned as being before the workman. The ware is then taken into a stove and dried sufficiently hard to be put upon the lathe and undergo the operation of turning or smoothing the outer surface. Throwing.

This lathe is of the like construction as the common lathe used in wood turning, and needs no description here. Turning, &c.

The ware is then given to another workman, who puts on the handles and feet, or such ornaments as may have to be fixed on the body of the ware; and after being thoroughly dried, it is ready for the first or biscuit firing.

It must be observed, that only articles of a circular form can be produced on the wheel or from the lathe. All others, as well as the feet and handles and ornaments, are made by different workmen, from moulds of gypsum or of baked ware. An earthen-ware called *dipped ware* is made of different colours, some of which are very striking, by being dipped into a slip or wash of the same clay, or of other clays coloured by metallic oxyds finely ground and mixed up with the wash. This operation is performed at the lathe, before the ware has had time to get dry or hard.

The ware being made dry, is placed in saggers (cases), which are piled on each other until the oven is filled up nearly to the top of the dome. Fire is then applied in mouths round the outside of the oven, having flues round the inside, and under the bottom of the oven, communicating with the mouths. The fire is applied very gradually, the operation requiring from forty-eight to fifty hours. As a test to show when the necessary degree of heat is obtained, small round caps made of common brick-clay are put into a sagger, opposite a small opening in the oven, which the fireman draws out from time to time, judging, from the degree of colour the test or trial had acquired, which was produced by the oxyd of iron contained in the clay, how to regulate his further operations. Firing and baking.

The operation of glazing is similar to that detailed in the article on porcelain, but is performed with much less diffi- Glazing.

Poulton ‖ Poussin.

culty, and with a greater degree of certainty, on a porous than on a vitrified surface. After the ware is glazed (a considerable portion of which is first painted, and printed on the body, a biscuit), the ware is then again placed into the saggers or cases, and placed as before to undergo the second firing. In this second firing for the glazing, a much lower degree of heat is applied than for the biscuit-ware, and the operation is performed in fifteen or eighteen hours, according to the size of the oven. The painting or enamelling, and the printing on earthen-ware, are done in the same manner as that described on porcelain, which need not here be repeated.

The extent to which the manufacture of pottery wares is now carried on in this country, in which porcelain may be included, together with its usefulness and excellence, has rendered it a subject of great national importance. The raw materials are of home production, and of little intrinsic value, the transport of which affords to the coasting trade a freightage of from 40,000 to 50,000 tons annually. The manufactured articles are wholly produced by manual labour, which is not likely to be superseded by machinery, while the export of the bulky article of earthen-ware to all parts of the world gives employment, to an immense extent, to the shipping of this and other countries. Nor is this interesting manufacture without some claim in furthering the progress of the fine arts, by the cultivation of painters, engravers, and modellers, many of whom have displayed talents of a superior order in their respective lines. In flower-painting, the specimens exhibited in the work of English artists cannot be excelled. In figure-painting, owing to the want of schools for design, the porcelain painters of this country have not made much progress; but in flower-painting, and in decoration generally, our British artists cannot be surpassed.

There are some considerable manufactories of pottery ware in the north of England, and one or two in Yorkshire; but the principal site of both pottery and porcelain wares is in the newly created borough of Stoke-upon-Trent, which contains a population of nearly 60,000 persons, engaged either directly or indirectly in these manufactures. On the passing of the reform bill, this borough was considered of sufficient importance to have its great interests represented by two members in parliament. (B. A.)

POULTON, a market-town in the county of Lancaster, and hundred of Amounderness, 235 miles from London. It is on the sea-shore, near the mouth of the river Wye, and communicates by a canal with most of the rivers of the county. It has a market on Monday. The population of the town was, in 1801, 769; in 1810, 926; in 1821, 1011; and in 1831, 1025; but the whole parish contains five townships, and at the last census 4080 inhabitants.

POULTRY, all kinds of domestic fowls brought up in yards, as cocks, hens, and the like. See AGRICULTURE.

POUND, a standard weight, for the proportion and subdivisions of which, see the article WEIGHTS AND MEASURES.

POUND also denotes a money of account, so called because the ancient pound of silver weighed a pound troy.

POUNDAGE, a subsidy of twelve pence in the pound, granted to the crown on all goods and merchandises exported or imported; and if by aliens, one penny more.

POUSSIN, NICHOLAS, an eminent French painter, born in 1594, at Andel, a little city in Normandy, where his father was of noble extraction, but born to a small estate. Being invited to Paris by Louis XIII., who assigned him a pension and lodgings in the Tuilleries, he painted for Prince Justiniani an historical picture representing Herod's cruelty; an admirable composition, in which he gave such expression to every character, as could not fail to strike the beholder with terror and pity. He then laboured for several years on the celebrated pictures of the seven sacraments of the Catholic church. But none of Poussin's designs have been more generally admired than that of the death of Germanicus, which would have gained him immortal honour if he had never painted another picture. He began the labours of Hercules in the gallery of the Louvre; but the faction of Vouet's school railing at him and his performances, put him so out of humour with his own country, that he returned to Rome, where he died in 1665. He never went beyond easel-pieces, for which he had a perpetual demand; and his method was to fix the price he expected on the back of the canvass, which was readily paid.

Poussin ‖ Prague.

POUSSIN, *Gaspar*. This painter, whose real name was *Dughet*, was born at Paris in 1600, and was induced to travel to Rome, not only from a love of the art of painting, but also to visit his sister, who was married to Nicholas Poussin. Sandrat says that Gaspar was employed at first only to prepare the pallet, pencils, and colours for Nicholas; but by the precepts and example of that excellent master, he gradually rose to the highest reputation, and is undoubtedly one of the best landscape painters that ever appeared. Whilst he continued at Rome he dropped his own name, and assumed that of his brother-in-law and benefactor, by which only he is now known. He died in 1662.

POUTEOU, or POOTOO, a small island off the coast of China, a little to the east of Tehnsan. It is represented as a beautiful spot, containing numerous temples.

POVERTY BAY, on the east coast of New Holland, in the South Pacific Ocean, discovered by Captain Cook in 1769. Long. 181. 36. W. Lat. 38. 42. S.

POWALLY, a town of Hindustan, in the province of Tinnevelly, twenty miles south-west from Madura. Long. 77. 59. E. Lat. 9. 39. N.

POWANGHUR, a celebrated hill-fort of Hindustan, province of Gujerat. It rises nearly perpendicular to the immense height of six hundred yards, and is inaccessible except on the north side, which is fortified with fine walls. A small rock rises on the summit, on which stands a Hindu temple. It was taken by the British, after a very slight resistance, in 1803. Long. 73. 39. E. Lat. 22. 31. N.

PRACELS, a range of small islands and rocks in the Chinese Sea, about sixty miles to the east of Cochin-China. They are of dangerous navigation, from the currents that run between them. Length, 300 miles; breadth, 60; from long. 110. to 111. E. and lat. 11. 40. to 16. 10. N.

PRÆMUNIRE, in *English Law*, a writ of citation.

PRÆNESTE, in *Ancient Geography*, a town of Latium, to the south-east of Rome, towards the territory of the Æqui. It is a place of great strength, and famous for the temple and oracle of Fortune, called *Sortes Prænestinæ*.

PRAGMATIC SANCTION, in the civil law, is defined by Hottoman to be a rescript or answer of the sovereign, delivered by advice of his council, to some college, order, or body of people, upon consulting him on some case of their community. The like answer given to any particular person is called simply rescript.

The term pragmatic sanction is chiefly applied to a settlement of Charles VI. emperor of Germany, who, in the year 1722, having no sons, settled his hereditary dominions on his eldest daughter, the archduchess Maria Theresa, which was confirmed by the diet of the empire, and guaranteed by Great Britain, France, the States-General, and most of the powers in Europe.

PRAGUE, a city, the capital of the Austrian kingdom of Bohemia. It is nearly in the centre of the kingdom, on the river Moldau, which runs to the Elbe on its way to the ocean, and divides the city into two parts. There is over the river one of the finest ancient bridges in Europe, 1800 feet in length, consisting of sixteen arches, and adorned with twenty-eight statues of saints and martyrs.

The city is built on seven hills, and the streets are consequently irregular; the houses are very antique and large, and the compass of the whole is said to be nine miles. It

Praam
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Pratt.

contains numerous public buildings, amongst others the metropolitan cathedral, dedicated to St. Beit, with twelve highly-decorated side chapels, besides which, are no less than forty-six other Catholic churches, and several monasteries and nunneries. The palace of the ancient kings of Bohemia has been converted into a citadel; but a more modern one, now used as a Stadthouse, is of vast extent, containing 150 apartments, with a hall near equal in size to that of Westminster. There is a university, one of the oldest in Germany, in which degrees are obtained in the four faculties of law, medicine, theology, and philosophy. It has connected with it a library of 100,000 volumes; a botanic garden, an astronomical observatory, and collections of natural history. There are forty-four professors, and the students, which were in 1816, only 8798, had increased, and in 1823, were 1348. This seminary may be considered the birthplace of the reformation of religion, as John Huss and Jerome exercised in it the right of free inquiry, and became victims to it nearly one hundred years before the appearance of Luther. There are also several societies for the promotion of learning, of the sciences, and of the fine arts. The institutions for the maintenance of the poor, for affording medical aid, and for other benevolent purposes, are numerous and well conducted. The inhabitants, like those of all Europe, have greatly increased since the treaty of Vienna in 1815. In that year they were 67,730 Christians, and 6,783 Jews; in 1817, they were 79,606, from which, by regular increase, they had grown up, in 1827, to 107,325.

The chief trade is that which arises from its central position, and from its being the seat of the local government; but there are manufactures of gold, silver, jewellery, and other luxuries, as well as others, for internal consumption, of silk, cotton, linen, and woollen goods, and for cutlery and haberdashery wares; there are also large breweries and distilleries. The city is fortified; but, from being commanded by hills, is scarcely defensible; but it has been the theatre of many bloody actions. A battle was fought in 1620 on the white plains a few miles from the city, between the Elector Palatine and the Austrians, when the success of the latter caused the independence of Bohemia to expire. It was besieged by the French in 1751, and by the Prussians, who bombarded it in 1757; but in both cases the resistance was attended with success. Lat. 50. 5. 33. Long. 14. 49. 40.

PRAAM, a kind of lighter used in Holland and the ports of the Baltic sea, to carry the cargo of a merchant-ship alongside, in order to lade or to bring it to shore to be lodged in the storehouses after being discharged out of the vessel.

PRATINAS, a Greek poet contemporary with Æschylus, and born at Phlius. He was the first amongst the Greeks who composed satires, which were represented as farces. Of these, thirty-two were acted, as also eighteen of his tragedies, one of which only obtained the poetical prize. Some of his verses are extant, quoted by Athenæus.

PRATO, a city of the duchy of Tuscany, in Italy, the capital of a district called a vicarate, of the same name, in the circle of Florence. It stands on the river Bisenzeo. It is surrounded with walls and ditches. It contains some handsome plazas, a theatre, a cathedral, twelve parish and seventeen monastic churches, four hospitals, and 10,000 inhabitants, who make linen and woollen cloths, paper, copper ware, and other articles, and draw from quarries some good millstone.

PRATT, CHARLES, Earl of Camden, was the third son of Sir John Pratt, knight, chief-justice of the Court of King's-Bench under George I. by his second wife Elizabeth, daughter of the Reverend Hugh Wilson, canon of Bangor, and was born in 1713, the year before his father was called to the honour of the bench. He received the first rudiments of his education at Eton, and afterwards removed to King's College, Cambridge. Of his early life at both places little is known, other than that at college he was found to be remarkably diligent and studious, and particularly so in the history and constitution of this country. By some he was thought to be a little too tenacious of the rights and privileges of the college he belonged to; but perhaps it was to this early tendency that we are indebted for those noble struggles in defence of liberty, which, whether in or out of office, he displayed throughout the whole course of his political life. After remaining the usual time at college, and taking his master's degree, in 1739 he entered himself a student of the Inner Temple, and was in due time admitted by the honourable society as a barrister-at-law. And here a circumstance developes itself in the history of this great man, which shows how much chance governs in the affairs of this world, and that the most considerable talent and indisputable integrity will sometimes require the introduction of this mistress of the ceremonies, in order to obtain that which they ought to possess from their own intrinsic qualifications.

Pratt.

Mr. Pratt, after being called to the bar, notwithstanding his family introduction, and his own personal character, was very near nine years in the profession, without ever getting in any degree forward. Whether this arose from a natural timidity of constitution, ill-luck, or perhaps a mixture of despondence growing out of the two circumstances, it is now difficult to tell. But the fact was so; and he was so dispirited by it, that he had some thoughts of relinquishing the profession of the law, and retiring to his college, where, in rotation, he might be sure of a church living, that would give him a small but honourable independence. With these melancholy ideas he went as usual the western circuit, to make one more experiment, and then to take his final determination. Mr. Henley, afterwards Lord Northington, and chancellor of England, was in the same circuit. He was Mr. Pratt's most intimate friend; and he now availed himself of that friendship, and told him his situation, and his intentions of retiring to the university and going into the church. He opposed his intention with strong raillery, and got him engaged in a cause along with himself; and Mr. Henley being ill, Mr. Pratt took the lead, and displayed a professional knowledge and elocution that excited the admiration of his brother barristers as much as that of the whole court. He gained his cause; and besides, he acquired the reputation of an eloquent, profound, and constitutional lawyer. It was this circumstance, together with the continued good offices of his friend Henley, which led to his future greatness; for with all his abilities and all his knowledge, he might otherwise in all probability have passed his life in obscurity, and gone down to the grave unnoticed and unknown.

He now became one of the most successful pleaders at the bar, and honours and emoluments flowed thick upon him. He was chosen to represent the borough of Downton, Wiltshire, after the general election in 1759; recorder of Bath 1759; the same year he was appointed attorney-general; and in January 1762 he was called to the degree of serjeant at law, appointed chief-justice of the common pleas, and knighted. His lordship presided in that court with a dignity, weight, and impartiality, never exceeded by any of his predecessors; and when John Wilkes was seized and committed to the Tower on an illegal general warrant, his lordship, with the intrepidity of a British magistrate, and the becoming fortitude of an Englishman, granted him an *habeas corpus*, and on his being brought before the court of common pleas, discharged him from his confinement in the Tower, 6th May 1763, in a speech which did him honour. His wise and spirited behaviour on this remarkable occasion, was so acceptable to the nation, that the city of London presented him with the freedom of their corporation in a gold box.

On the 16th of July 1765 he was created a peer of Great

Praslin ‖ Prayer.

Britain, by the style and title of Lord Camden, Baron Camden, in the county of Kent; and, on the 30th July 1766, on the resignation of Robert Earl of Northington, he was appointed lord high chancellor of Great Britain. In this capacity he, in a speech of two hours, declared, upon the first decision of the suit against the messengers who arrested Mr. Wilkes, that it was the unanimous opinion of the whole court, that general warrants, except in cases of high treason, were illegal, oppressive, and unwarrantable. He conducted himself in this high office so as to obtain the love and esteem of all parties; but when the taxation of America was in agitation, having declared himself against it, and strongly opposed it, he was removed from his station in 1770.

Upon the fall of Lord North he was again taken into the administration, and on the 27th of March 1782, appointed president of the council; an office which he resigned in March 1783. On the 13th of May 1786, he was created Viscount Bayham of Bayham Abbey, Kent, and Earl Camden. He died on the 18th of April 1794 at his house in Hill Street, Berkeley Square, being at that time president of his Majesty's most honourable privy council. He married Elizabeth, daughter and co-heir of Mr. Nicholas Jeffery, son and heir of Sir Jeffery Jefferys of Brecknock Priory, knight, who died in December 1779, and by whom he had issue John Jefferys Pratt, born 1759, and several daughters.

PRASLIN, an island in the eastern seas, one of the group called the Sechettis. It contains an excellent harbour, well sheltered by small islands from every wind. The interior is lofty, and covered with trees. Long. 55. 47. E. Lat. 4. 19. S.

PRATUS ISLES, a cluster of islands, shoals, and large rocks, in the Chinese sea, about 300 miles S.S.E. of Canton. The principal island, called Prata, is surrounded by a very extensive shoal of uncertain extent. They are six leagues in extent from north to south, and stretch three or four leagues to the east. Long. 116. 45. E. Lat. 23. 50. N.

PRAXAGORAS, a native of Athens, who, at nineteen years of age composed the History of the Kings of Athens, in two books; and at twenty-two wrote the Life of Constantine the Great, in which, though a pagan, he speaks very advantageously of that prince. He also wrote the History of Alexander the Great. Praxagoras lived under Constantine, about the year 345.

PRAXITELES, a very famous Greek sculptor, who lived 330 years before Christ, during the reign of Alexander the Great. All the ancient writers mention his statues with high commendation, especially a Venus executed by him for the city of Cnidus, which was so admirable a piece, that Nicomedes offered to release the inhabitants from their tribute as the purchase of it; but they refused to part with it. The inhabitants of the isle of Cos requested of Praxiteles a statue of Venus; and in consequence of this application the artist gave them their choice of two, one of them representing the goddess entirely naked, and the other covered with drapery. Both of these were of exquisite workmanship. Although the former was esteemed the most beautiful, nevertheless the inhabitants of Cos had the wisdom to give the preference to the latter, from a conviction that no motive whatever could justify their introducing into their city any indecent statues or paintings, which are so likely to inflame the passions of young people, and lead them to immorality and vice.

PRAYER, a solemn address to God, which, when it is of any considerable length, consists of *adoration*, *confession*, *supplication*, *intercession*, and *thanksgiving*.

By *adoration* we express our sense of God's infinite perfections, his power, wisdom, goodness, and mercy; and acknowledge that our constant dependence is upon Him by whom the universe was created and has been hitherto preserved. By *confession* is meant our acknowledgment of our manifold transgressions of the divine laws, and our consequent unworthiness of all the good things which we enjoy at present, or expect to be conferred upon us hereafter. In *supplication* we entreat our omnipotent Creator and merciful Judge, not to deal with us after our iniquities, but to pardon our transgressions, and by his grace to enable us to live henceforth righteously, soberly, and godly, in this present world; and by Christians this intreaty is always made in the name and through the mediation of Jesus Christ, because to them it is known that there is none other name under heaven given unto men whereby they may be saved. To these supplications for mercy, we may likewise add our prayers for the necessaries of life, because if we seek *first* the kingdom of God, and his righteousness, we are assured that such things shall be added unto us. *Intercession* signifies those petitions which we offer up for others, for friends, for enemies, for all men, especially for our lawful governors, whether supreme or subordinate. And *thanksgiving* is the expression of our gratitude to God, the giver of every good and perfect gift, for all the benefits enjoyed by us and others, for the means of grace, and for the hope of glory. Such are the component parts of a regular and solemn prayer, adapted either for the church or for the closet. But an ejaculation to God, conceived on any emergency, is likewise a prayer, whether it be uttered by the voice, or suffered to remain a mere affection of the mind; because the being to whom it is addressed discerneth the thoughts of the heart. Prayer.

That prayer is a duty which all men ought to perform with humility and reverence, has been generally acknowledged as well by the untaught barbarian as by the enlightened Christian; and yet to this duty objections have been made by which the understanding has been bewildered in sophistry and affronted with jargon. "If God be independent, omnipotent, and possessed of every other perfection, what pleasure, it has been asked, can he take in our ac knowledgment of these perfections? If he knows all things past, present, and future, where is the propriety of our confessing our sins unto him? If he is a benevolent and merciful Being, he will pardon our sins, and grant us what is needful for us without our supplications and entreaties; and if he be likewise possessed of infinite wisdom, it is certain that no importunities of ours will prevail upon him to grant us what is improper, or for our sakes to change the equal and steadv laws by which the world is governed.

> Shall burning Ætna, if a sage requires
> Forget to thunder, and recal her fires?
> On air or sea new motions be imprest,
> O blameless Bethel, to relieve thy breast?
> When the loose mountain trembles from on high,
> Shall gravitation cease, if you go by?
> Or some old temple, nodding to its fall,
> For Chartres' head reserve the hanging wall?

Such are the most plausible objections which are usually made to the practice of prayer; and though they have been set off with all the art of the metaphysical wrangler, and embellished with all the graces of the poetry of Pope, they appear to us such gross sophisms as can operate only on a very unthinking head, or on a very corrupt heart. For if God certainly exists, and there is not a mathematical theorem capable of more rigid demonstration, it is obvious that no man can think of such a Being without having his mind strongly impressed with the conviction of his own constant dependence upon him; nor can he "contemplate the heavens, the work of God's hands, the moon and the stars which he has ordained," without forming the most sublime conceptions that he can of the Divine power, wisdom, and goodness. But such conviction, and such conceptions, whether clothed in words or not, are to all intents and purposes what is meant by adoration; and are as well known to the Deity

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whilst they remain the silent affections of the heart, as after they are spoken in the beginning of a prayer. Our adoration, therefore, is not expressed for the purpose of giving information to God, who understands our thoughts afar off; but merely, when the prayer is private, because we cannot think any more than speak without words, and because the very *sound* of words that are well chosen affects the heart, and helps to fix our attention. And as the Being who sees at once the past, present, and to come, and to whom a thousand years are but as one day, stands not in need of our information; so neither was it ever supposed by a man of rational piety, that he takes pleasure on his *own* account in hearing his perfections enumerated by creatures of yesterday; for being independent, he has no passions to be gratified, and being self-sufficient, he was as happy when existing alone as at that moment "when the morning stars sang together, and all the sons of God shouted for joy." Adoration is therefore proper only as it tends to preserve in our minds just notions of the Creator and Governor of the world, and of our own constant dependence upon him; and if such notions be useful to ourselves, who have a part to act in the scale of existence, upon which our happiness depends, a proposition which no theist will controvert, adoration must be acceptable to that benevolent God, who, when creating the world, could have no other end in view than to propagate happiness.

By the same mode of reasoning, it will be easy to show the duty of *confession* and *supplication*. We are not required to confess our sins unto God, because he is ignorant of them; for he is ignorant of nothing. If he were, no reason could be assigned for our divulging to our judge actions deserving of punishment. Neither are we required to cry for mercy, in order to move him in whom there is no variableness, nor any shadow of turning. The Being that made the world, governs it by laws that are inflexible, because they are the best; and to suppose that he can be induced by prayers, oblations, or sacrifices, to vary this plan of government, is an impious thought, which degrades the Deity to a level with man. One of these inflexible laws is the connection established between certain dispositions of mind and human happiness. We are enjoined to pursue a particular course of conduct under the denomination of virtue, not because our virtuous actions can in any degree be of advantage to him by whom we are created, but because they necessarily generate in our own minds those dispositions which are essential to our ultimate happiness. A man of a malignant, arrogant, or sensual disposition, would have no enjoyment in that heaven, where all are actuated by a spirit of love and purity; and it is doubtless for this reason amongst others, that the Christian religion prohibits malice, arrogance, and sensuality, among her votaries, and requires the cultivation of the opposite virtues. But a person who has deviated far from his duty cannot think of returning, unless he be previously convinced that he has gone astray. Such conviction, whenever he obtains it, will necessarily impress upon his mind a sense of his own danger, and fill his heart with sorrow and remorse for having transgressed the laws established by the most benevolent of all Beings for the propagation of universal felicity. This conviction of error, this sense of danger, and this compunction for having transgressed, are all perceived by the Deity as soon as they take place in the mind of the sinner; and he is required to *confess* his sins, only because the act of confession tends to imprint more deeply on his mind his own unworthiness, and the necessity of returning immediately into the paths of that virtue of which all the ways are pleasantness, and all the paths are peace.

In the objection, it is taken for granted, that if God be a benevolent and merciful Being, he will pardon our sins, and grant us what is needful for us, whether we supplicate him or not; but this is a gross and palpable mistake, arising from the objector's ignorance of the end of virtue and the nature of man. Until a man be sensible of his sins and his danger, he is, for the reason already assigned, incapable of pardon, because his disposition is incompatible with the happiness of the blessed. But whenever he acquires this conviction, it is impossible for him not to form a mental wish that he may be pardoned; and this wish being perceptible to the all-seeing eye of his Judge, forms the sum and substance of a supplication for mercy. If he clothe it in words, it is only for a reason similar to that which makes him adore his Creator and confess his sins in words, that just notions may be more deeply imprinted on his own mind. The same reasoning holds good with respect to those prayers which we put up for temporal blessings, for protection and support in our journey through life. We are told by the highest authority, that "the Lord is nigh unto all them that call upon him, to all that call upon him in truth." This, however, is not because he is attracted or delighted by their prayers and entreaties, but because those prayers and entreaties fit such as offer them for receiving those benefits which he is at all times ready to pour upon all mankind. In his essence God is equally present with the righteous and with the wicked, with those who do pray, and with those who do not; for "the eyes of the Lord are in every place, beholding the evil and the good." But as the atmosphere equally surrounds every person upon this globe, and yet in its state of greatest purity does not affect the asthmatic as it affects those who are whole; so the Divine presence, though essentially the same everywhere, yet does not protect the impious as it protects the devout, because the impious are not in a state capable of the Divine protection. The end for which God requires the exercise of prayer as a duty, is not his benefit, but ours; because it is a mean to generate in the petitioner such a disposition of mind as must render him a special object of that love and that providential care which extend over the whole creation.

That part of the objection which results from the consideration of the fixed laws of nature, and which the poet has so finely illustrated, presents, it must be confessed, considerable difficulties; but none which to us appear insurmountable. If, indeed, we suppose that in the original constitution of things, when the laws of nature were established, a determinate duration was given to the top of the mountain and the nodding temple, without any regard to foreseen consequences, it would undoubtedly be absurd and perhaps impious to expect the law of gravitation to be suspended by the prayers of a good man, who should happen to be passing at the instant decreed for the fall of these objects. But of such a constitution there is so far from being evidence, that it appears not to be consistent with the wisdom and goodness of the Author of nature. This world was undoubtedly formed for the habitation of man and of other animals. If so, we must necessarily suppose, that in the establishing of the laws of nature, God adjusted them in such a manner as he saw would best serve the accommodation of those sentient beings for whose accommodation alone they were to be established. Let it then be admitted, that all the human beings who were ever to exist upon this globe, with all their thoughts, words, and actions, were at that important moment present to the divine intellect, and it will surely not be impossible to conceive that in consequence of the foreseen danger and prayers of a good man, the determinate duration of the mountain and the tower might be either lengthened or shortened to let him escape. This idea of providence, and of the efficacy of prayer, is thus illustrated by Mr. Wollaston. "Suppose M (some man) certainly to *foreknow*, by some means or other, that, when he should come to be upon his death-bed, L would *petition* for some *particular legacy*, in a manner so earnest and humble, and with such a good disposition, as would render it proper to grant his request; and upon this, M makes his *last will*, by which he devises to L that which was to be asked, and then locks up the *will*; and all this many years

Prayer. before the death of M, and whilst L had yet no expectation or thought of any such thing. When the time comes, the *petition* is made and *granted;* not by making any *new* will, but by the old one already made, and without alteration; which legacy had, notwithstanding that, never been left, had the petition never been preferred. The grant may be called the effect of a future act, and depends as much upon it as if it had been made after the act. So, if it had been foreseen, that L would not *so much as ask*, and he had been therefore left out of the will, this *præterition* would have been caused by his carriage, though much later than the date of the will. In all this nothing is hard to be admitted, if M be allowed to foreknow the case. And thus the *prayers* which good men offer to the *all-knowing* God, and the *neglect of prayers* by others, may find fitting effects *already* forecasted in the course of nature."

This solution of the difficulty presents indeed to the mind a prodigious scheme, in which all things to come are, as it were, comprehended under one view, and estimated and compared together. But when it is considered what a mass of wonders the universe is in other respects; what an incomprehensibly great and perfect being God is; that he cannot be ignorant of any thing, no not of the future wants and deportments of particular men; and that all things which derive their existence from him must be consistent with one another, it must surely be confessed that such an adjustment of physical causes to moral volitions is within the compass of infinite power and perfect wisdom.

To that part of a prayer which we have termed intercession, it has been objected, that "to intercede for others is to presume that we possess an interest with the Deity upon which their happiness and even the prosperity of whole communities depends." In answer to this objection, it has been observed by an ingenious and useful writer (Dr. Paley), that "how unequal soever our knowledge of the Divine economy may be to a complete solution of this difficulty, which may require a comprehension of the entire plan, and of all the ends of God's moral government, to explain it satisfactorily, we can yet understand one thing concerning it, that it is, after all, nothing more than the making of one man the instrument of happiness and misery to another; which is perfectly of a piece with the course and order that obtain, and which we must believe were intended to obtain, in human affairs. Why may we not be assisted by the *prayers* of other men, as well as we are beholden for our *support to their labour?* Why may not our happiness be made in some cases to depend upon the intercession as it certainly does in many upon the good offices of our neighbours? The happiness and misery of great numbers we see oftentimes at the disposal of one man's choice, or liable to be much affected by his conduct; what greater difficulty is there in supposing, that the prayers of an individual may avert a calamity from multitudes, or be accepted to the benefit of whole communities."

These observations may perhaps be sufficient to remove the force of the objection, but much more may be said for the practice of mutual intercession. If it be one man's duty to intercede for another, it is the duty of that other to intercede for him; aud if we set aside the particular relations which arise from blood, and from particular stations in society, mutual intercession must be equally the duty of all mankind. But there is nothing (we speak from our own experience, and appeal to the experience of our readers), which has so powerful a tendency to generate in the heart of any person good-will towards another, as the constant practice of praying to God for his happiness. Let a man regularly pray for his enemy with all that seriousness which devotion requires, and he will not long harbour resentment against him. Let him pray for his friend with that ardour which friendship naturally inspires, and he will perceive his attachment to grow daily and daily stronger. If, then, universal benevolence, or charity, be a disposition which we ought to cultivate in ourselves, mutual intercession is undeniably a duty, because nothing contributes so effectually to the acquisition of that spirit which an apostle terms the end of the commandment. Prayer ‖ Precedence.

When it is said, that by interceding for kings, and all in authority, we seem to consider the prosperity of communities as depending upon our interest with God, the objector mistakes the nature and end of these intercessions. In the prosperity of any community consists great part of the happiness of its individual members; but that prosperity depends much upon the conduct of its governors. When, therefore, individuals intercede for their governors, the ultimate object of their prayers must be conceived to be their own good.

Having evinced the duty of adoration, confession, supplication, and intercession, we need not surely waste our readers' time with a formal and laboured vindication of thanksgiving. Gratitude for benefits received is so universally acknowledged to be a virtue, and ingratitude is so detestable a vice, that no man who lays claim to a moral character will dare to affirm that we ought not to have a just sense of the goodness of God. (H.H.H.H)

PREADAMITE, a denomination given to the inhabitants of the earth, conceived, by some people, to have lived before Adam.

In 1655, Isaac de la Pereyra published a book to evince the reality of Preadamites, and gained a considerable number of proselytes to his opinion; but the answer of Desmarets, professor of theology at Groningen, published the year following, put a stop to its progress, though Pereyra made a reply.

PREBEND, the maintenance a prebendary receives out of the estate of a cathedral or collegiate church. Prebends are distinguished into simple and dignitary. A simple prebend has no more than the revenue for its support; but a prebend with dignity has always a jurisdiction annexed to it.

PREBENDARY, an ecclesiastic who enjoys a prebend. The difference between a prebendary and a canon is, that the former receives his prebend in consideration of his officiating in the church, but the latter merely by his being received into the cathedral or college.

PRECEDENCE, a place of honour to which a person is entitled. This is either of courtesy or of right. The former is that which is due to age, estate, or the like, and is regulated by custom and civility; the latter is settled by authority, and when invaded, gives an action at law.

In Great Britain, the order of precedency is as follows: The king, the princes of the blood, the archbishop of Canterbury, the lord high chancellor, the archbishop of York, the lord treasurer of England, the lord president of the council, the lord privy seal, dukes, the eldest sons of dukes of the blood royal, marquises, dukes' eldest sons, earls, marquises' eldest sons, dukes' younger sons, viscounts, earls' eldest sons, marquises' younger sons, bishops, barons, speaker of the house of commons, lord commissioner of the great seal, viscounts' eldest sons, earls' younger sons, barons' eldest sons, privy counsellors not peers, chancellor of the exchequer, chancellor of the duchy, knights of the Garter not peers, lord chief justice of the king's bench, master of the rolls, lord chief justice of the common pleas, lord chief baron of the exchequer, puisne judges and barons, knights banneret if made in the field, masters in chancery, viscounts' younger sons, barons' younger sons, baronets, knight banneret, knights of the Bath, knights batchelors, baronets' eldest sons, knights' eldest sons, baronets' younger sons, knights' younger sons, field and flag officers, doctors graduate, serjeants at law, esquires, gentlemen bearing coat armour, yeomen, tradesmen, artificers, labourers. It is to be observed, the ladies, except those of archbishops, bishops, and judges, take place according to the degree of quality of their husbands; and unmarried ladies take place according to that of their fathers.

PRECESSION OF THE EQUINOXES.

Precession of the Equinoxes.

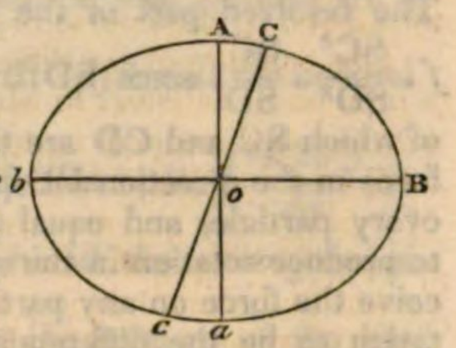
In the article Astronomy (vol. vi. p. 767), the phenomenon of the annual precession of the equinoxes has been described, and its physical cause stated to be the attraction of the sun and moon upon the protuberant mass of matter accumulated about the earth's equator, combined with the diurnal rotation. We shall here discuss the subject more particularly, and shew in what manner the different forces which tend to displace the plane of the earth's equator give rise to the phenomenon in question, and how their effects are computed from the fundamental principles of dynamics. The general problem, which is that of determining the perturbations of the earth's axis of rotation, embraces the *Nutation* of the axis, as well as the precessional motion of the equinoctial points, and is one of the most important and interesting in physical astronomy.

If the earth were a perfect sphere, the attraction of the sun or moon would have no tendency to communicate to it any motion about its centre of gravity. In this case, all the particles being symmetrically disposed with reference to every plane passing through its centre, the forces acting on opposite sides of any plane passing through its centre and the centre of the attracting body, would exactly balance each other, and consequently would have no tendency to produce a rotatory motion. But by reason of the spheroidal form of the earth, and the intensity of the force of attraction varying with the distance, the action of a distant body which is not situated either in the plane of the equator, or in the prolongation of the axis of rotation, produces an unequal effect on the opposite sides of every plane passing through the earth's centre, (excepting the meridian in which the body is situated), and tends to generate a rotatory motion about that diameter of the equator which is perpendicular to the line which joins the centre of the earth with the centre of the attracting body. Hence the sun exerts a force, which at every instant has a tendency to bring the plane of the earth's equator towards the plane of the ecliptic; and if the earth had no motion of rotation about its axis, the two planes would at length be brought to coincide. In consequence, however, of the rotatory motion, the inclination of the two planes, as we shall shew, undergoes no permanent alteration; but a motion is given to the earth's axis, such that the pole of the equator constantly revolves about the pole of the ecliptic in the direction opposite to that of the diurnal rotation, and the intersection of the equator and ecliptic, following the motion of the pole, is carried backwards along the ecliptic. The moon produces a similar effect in reference to the plane of the lunar orbit; and the motion produced by the combined action of the sun and moon, which is the phenomenon observed, is the *luni-solar* precession of the equinoxes.

As the efficacy of the disturbing force to turn the earth about an axis varies with the distance of the attracting body from the plane of the equator, the precessional motion of the equinoxes is not uniform. The efficacy of the sun's force continues to increase, whilst the sun passes from either equinox to the solstice, and to diminish while it passes from the solstice to the equinox. The period of the inequality is consequently half a-year. The period in which the action of the moon passes through all its degrees of intensity is about nine years, being that in which the nodes of the lunar orbit accomplish half a revolution on the ecliptic. The apparent effect of this irregular action, is an alternate increase and diminution of the declinations of the fixed stars, most sensible for those nearest the pole, which is characteristically called the *nutation* of the earth's axis. The solar nutation, however, is so small as to be insensible to observation; the lunar nutation is sufficiently sensible, amounting to about 18″ between the extreme positions of the pole.

Before proceeding with the investigation of the problem, it will be convenient to premise the two following elementary theorems respecting the composition of rotatory motion, referring the reader for their demonstration to the article Rotation.

Theorem 1. If a rigid body revolving about an axis Aa, which passes through its centre of gravity O, with an angular velocity $=v$, receive an impulse which alone would cause it to revolve about an axis Bb, also passing through its centre of gravity, with a velocity $=\phi$, the body will now revolve about a third axis Cc, passing through its centre of gravity, and lying in the plane of the two axes Aa and Bb, and so situated that the sine of its inclination to the axis Aa will be to the sine of its inclination to the axis Bb, as the velocity about Bb to the velocity about Aa; that is, the new axis will divide the angle AOB, so that sin AOC : sin BOC :: ϕ : v.



In order to determine whether the pole C of the new axis lies between A and B, or between A and b, it is only necessary to consider that the new axis must evidently be that line in the body in which every point is at rest in respect of both motions. If, therefore, we suppose the original motion about Aa, to be in the direction which would raise the point B above the plane of the paper, and to depress b below it, and the new impulse to be given in the direction which would depress the point A below the plane of the paper, and raise a above it, then C will lie between A and B; but if the new impulse tends to raise A above the plane of the paper, then C will lie between A and b.

Corollary 1. If the two axes Aa and Bb are at right angles, then sin BOC=cos AOC, and we have $\frac{\sin AOC}{\cos AOC} = \frac{\phi}{v}$, that is, tan AOC$=\frac{\phi}{v}$.

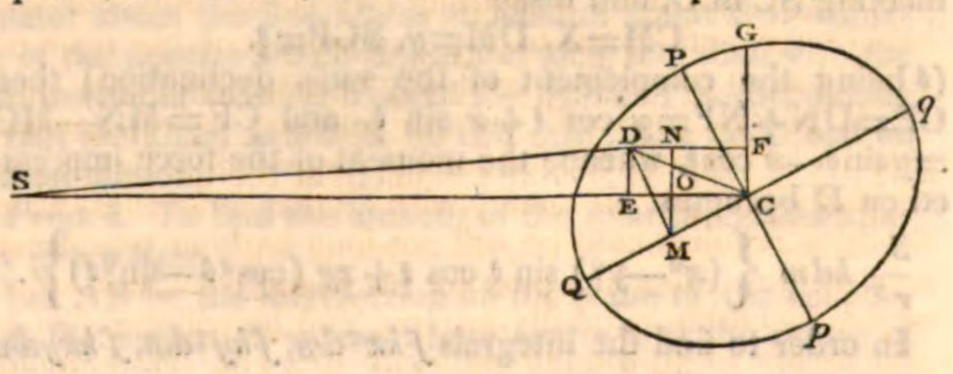
Cor. 2. If the impulse is renewed at every instant of time, the axis about which the body actually revolves must have a uniform motion in space from OA towards OB.

Theorem 2. If the force which tends to give the body a motion of rotation about an axis which is always perpendicular to the axis about which it is already revolving, and situated in the plane AOB, be uniform, the angular velocity of rotation remains unaltered, or v is a constant quantity.

These theorems, which are true of bodies in general, whatever be their figure, were first demonstrated by Frisi.

Proposition 1. To determine the efficacy of the sun's attraction to turn the spheroid about its centre, the earth being supposed homogeneous.

Let Pp be the axis of rotation, Qq the projection of the equator, S the sun, C the centre of the spheroid, and D



Precession of the Equinoxes.

the projection of a point in the interior of the spheroid on the plane PQ*pq*. Join SC, SD, DC; and draw CG perpendicular to SC, and DE, DF respectively perpendicular to SC, CG.

Let f represent the force of the sun's attraction on a particle at the centre C, and f' the force of its attraction on a particle at D, then the attraction being inversely as the square of the distance, we have $f' = f \cdot \frac{SC^2}{SD^2}$. Now the force f', which acts on D in the direction SD, may be resolved into two; one in the direction CD, which has no tendency to turn the spheroid about its centre, and the other in the direction FD parallel to SC, which tends to turn the spheroid in the direction PQ about an axis passing through C, and perpendicular to the plane PQ*pq*. The resolved part of the force f', in the direction FD is $f \cdot \frac{SC^2}{SD^2} \cdot \frac{SC}{SD}$, since SD is the diagonal of a parallelogram of which SC and CD are the sides. Now, if the resolved force in the direction FD parallel to SC were the same on every particle, and equal to f, it would have no tendency to produce rotation in the spheroid; we may therefore conceive the force on any particle which tends to produce rotation to be the difference between the part of the force acting on that particle in the direction parallel to SC, and the force f acting on the particle at C. Hence the force on D tending to impress a rotatory motion on the spheroid is $f \cdot \left(\frac{SC^2}{SD^2} \cdot \frac{SC}{SD} - 1\right) = f \cdot \frac{SC^3 - SD^3}{SD^3} = f \cdot \frac{(SC-SD)(SC^2+SC\cdot SD+SD^2)}{SD^3}$.

Now, by reason of the great distance of the sun in comparison of the radius of the earth, SD is very nearly parallel to SC, and equal to SC—CE. Substituting therefore SC—CE for SD, and neglecting terms divided by SC^2 which are so small as to be altogether insensible, the factor $\frac{SC^2+SC\cdot SD+SD^2}{SD^3}$ becomes $\frac{3}{SD}$, and consequently the above expression is reduced to $3f \cdot \frac{CE}{SD}$, or to $3f \cdot \frac{CE}{SC}$, since the difference between $1 \div SD$ and $1 \div SC$ is a quantity divided by SC^2, and therefore insensible. This is the part of the force on D which tends to turn the spheroid about the diameter of the equator which is perpendicular to Q*q*; and by the principles of mechanics, its efficacy in communicating a rotatory motion to the spheroid is proportional to the distance of its line of direction from the axis, that is, proportional to CF; whence the moment of the force at the point D becomes $3f \cdot \frac{CE \cdot CF}{SC}$.

Assume $r = SC$, and let S denote the absolute force of the sun, then $f = S \div r^2$; and if $k =$ the density at D, then kdm is the quantity of matter in the particle dm at D, and the moment of the force on that particle tending to produce in the spheroid a motion about its centre in the direction QP (which is the general direction of the motion produced by the forces on all the particles) is $-\frac{3S}{r^5} \cdot CE.CF.\ k.dm$, the integral of which must be taken for the whole spheroid.

Draw DM parallel to P*p*, and MN perpendicular to DF, meeting SC in O, and make

$$CM = X,\ DM = y,\ SCP = \theta,$$

(θ being the complement of the sun's declination) then $CE = DN + NF = y \cos\theta + x \sin\theta$, and $CF = MN - MO = y \sin\theta - x \cos\theta$, whence the moment of the force impressed on D becomes

$$\frac{3}{r^5} kdm \left\{ (x^2 - y^2) \sin\theta \cos\theta + xy (\cos^2\theta - \sin^2\theta) \right\}.$$

In order to find the integrals $\int kx^2 dm$, $\int ky^2 dm$, $\int kxy dm$ for every particle in the spheroid, let z be the co-ordinate perpendicular to the plane of the figure, and conceive the whole spheroid to be divided into an infinite number of thin slices parallel to the plane of yz, the thickness of each slice being dx; suppose, again, each slice to be divided into an infinity of parallelepipeds, parallel to the axis z, and terminated by the surface of the spheroid, the breadth of each being dy; and, lastly, let each parallelepiped be divided into an infinite number of lengths, each $= dz$. The element of the volume, dm, then becomes $dxdydz$; and consequently the sum of $kx^2 dm$ in respect of every particle is expressed by the triple integral $\iiint kx^2 dxdydz$.

Assuming x^2, dx and dy to be constant, and integrating with respect to z, we obtain $kx^2 dxdyz +$ const. Let $a =$ the semi-diameter of the equator, $b =$ the polar semi-axis, and the equation of the spheroid is $\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{a^2} = 1$, from which the limits of z must be found. This equation gives for a point at the surface, $z = \pm a\sqrt{1 - \frac{x^2}{a^2} - \frac{y^2}{b^2}}$, and between those values of z the definite integral becomes

$$2kax^2 dxdy \sqrt{1 - \frac{x^2}{a^2} - \frac{y^2}{b^2}}.$$

This expresses the sum of $kx^2 dm$ for the parallelepiped corresponding to a given value of x.

If we next suppose x^2 and dx to be constant, and integrate this expression with respect to y, we shall have the sum of $kx^2 dm$ for the slice, the distance of which from the plane yz is x. Make $1 - \frac{x^2}{a^2} = \frac{u^2}{b^2}$, or $u^2 = b^2 - \frac{b^2 x^2}{a^2}$, and the expression becomes $\frac{2kax^2 dx}{b}\sqrt{u^2 - y^2}.dy$. In integrating this expression, the limits of y, in respect of any given value of x, are obtained from the equation of the section of the ellipsoid in the plane xy, namely $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$. This equation gives $y^2 = b^2 - \frac{b^2 x^2}{a^2}$; whence, at the limits $y^2 = u^2$, and therefore $y = \pm u$. Now, by a known formula, the integral $\int \sqrt{u^2 - y^2}.dy$ from $y = -u$ to $y = +u$ is $\frac{1}{2}\pi u^2$ (π being the ratio of the circumference to the diameter); therefore the integral of $x^2 dm$ for the slice corresponding to a given value of x is $\frac{\pi kau^2 x^2 dx}{b}$; which, on substituting for u^2, its value $b^2 - \frac{b^2}{a^2}x^2$, becomes

$$\pi k \frac{b}{a}(a^2 x^2 - x^4)dx.$$

We have, lastly, to integrate this expression from $x = -a$ to $x = +a$. The integral between those limits is $\frac{2\pi kb}{a}\left(\frac{a^5}{3} - \frac{a^5}{5}\right)$; whence we have ultimately, in respect of the whole spheroid,

$$\iiint kx^2 dxdydz = \tfrac{4}{15}\pi ka^4 b.$$

On going through the same process for $y^2 dm$, or $y^2 dxdydz$, and observing that the integral $\int y^2 \sqrt{u^2 - y^2}.dy$ from $y = -u$ to $y = +u$ is $\frac{1}{8}\pi u^4$, there results for the whole spheroid

$$\iiint ky^2 dxdydz = \tfrac{4}{15}\pi ka^2 b^3.$$

With respect to the remaining integral $\int xydm$, it is easy to see that its value in respect of the whole spheroid must

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be 0, for on integrating $kxydxdydx$ with respect to x, there results $\frac{1}{2}kx^2ydydz$, which vanishes on giving x all values between $-t$ and $+t$, t being any definite quantity.

From these values of $\int x^2dm$, $\int y^2dm$, $\int xydm$, we obtain the following expression for the moment of all the forces impressed on the spheroid,

$$\frac{3S}{r^3}\cdot\frac{4\pi}{15}ka^2b(a^2-b^2)\sin\theta\cos\theta.$$

Prop. 2. To determine the efficacy of the sun's attraction to turn the spheroid about its centre, the earth being supposed heterogeneous.

Conceive the spheroid to be composed of infinitely thin concentric layers, bounded by spheroidal surfaces, and suppose the ellipticity and density to be different for each layer, but both to be functions of the distance from the centre of the spheroid. Let a and β be respectively the equatorial and polar semi-diameters of the layer which contains a particle dm, $e=$ its ellipticity, and k its density. In order to find the moment of all the forces impressed on the spheroid, we must first find an expression in terms of β, for their moment on the elementary layer containing dm, and then integrate this expression from $\beta=0$ to $\beta=b$. Now, suppose all the matter of the spheroid exterior to the layer in question to be removed, and suppose also for a moment the matter in the interior of the spheroidal surface passing through dm to be all of the same density, k, then the moment of the impressed forces on the spheroid whose surface passes through dm, is by the last proposition

$$\frac{3S}{r^3}\cdot\frac{4\pi}{15}ka^2\beta(a^2-\beta^2)\sin\theta\cos\theta.$$

The variable part of this expression is $ka^2\beta(a^2-\beta^2)$. Now, since $a=\beta(1+e)$, we have, on neglecting terms multiplied by e^2, which, by reason of the smallness of the earth's ellipticity are altogether insensible, $a^2=\beta^2+2\beta^2e$ and $a^2-\beta^2=2\beta^2e$, whence $ka^2\beta(a^2-\beta^2)=2k\beta^5e$. Suppose now the semi-axis β to receive an infinitely small increment, and to become $\beta+d\beta$; then since k and e are both functions of β, the expression $2k\beta^5e$ will become $2k\beta^5e+\frac{2d(k\beta^5e)}{d\beta}d\beta$. This is the variable part of the moment of the forces on the spheroid whose semiaxis is $\beta+d\beta$; consequently, in respect of the spheroidal layer which remains on subtracting the spheroid whose semiaxis is β, it becomes $\frac{2d(k\beta^5e)}{d\beta}d\beta$. Let the integral of this expression between the limits $\beta=0$ and $\beta=b$ be denoted by $2\,\mathrm{F}(\beta)$; then the moment of all the forces impressed on the spheroid supposed heterogeneous is

$$\frac{3S}{r^3}\cdot\frac{8\pi}{15}\mathrm{F}(\beta)\sin\theta\cos\theta.$$

Prop. 3. To determine the angular velocity ϕ generated by the sun's force, and the position of the equator after the infinitely small time dt.

By dynamics, the angular velocity of rotation is equal to the moment of the impressed forces divided by the moment of inertia of the mass to be moved. Now, the moment of inertia of a body, with respect to a given axis of rotation, is the sum of the products obtained by multiplying each particle of the body into the square of its distance from the axis; that is, in respect of the axis z, about which the impressed forces tend to turn the spheroid, the moment of inertia is $\int(x^2+y^2)dm$, supposing the spheroid homogeneous, and the density $k=1$. But it has been shewn that in this case $\int x^2dm=\frac{4}{15}\pi a^4b$, and $\int y^2dm=\frac{4}{15}\pi a^2b^3$; therefore the moment of inertia of the spheroid is $\frac{4}{15}\pi a^2b(a^2+b^2)$. And by prop. 1, the moment of the impressed forces is $\frac{3S}{r^3}\cdot\frac{4}{15}\pi a^2b(a^2-b^2)\sin\theta\cos\theta$, therefore

$$\phi=\frac{3S}{r^3}\cdot\frac{a^2-b^2}{a^2+b^2}\sin\theta\cos\theta.$$

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In the case of the heterogeneous spheroid the moment of inertia is thus found. As before, let a and β be the equatorial and polar semiaxes of the spheroidal surface passing through the particle dm, then if the matter within this surface be supposed of uniform density $=k$, the moment of inertia of this spheroid, by what is already shewn, is $\frac{4}{15}\pi ka^2\beta(a^2+\beta^2)$. But $a^2+\beta^2=2\beta^2+2\beta e$, and $a^2\beta=\beta^3+2\beta^3e$, therefore $a^2\beta(a^2+\beta^2)=2\beta^5+6\beta^5e$; and since e is a very small quantity, the second term of this expression is very small, and may be neglected in comparison of the first; therefore $ka^2\beta(a^2+\beta^2)=2k\beta^5$. For the spheroid whose semiaxis is $\beta+d\beta$, this quantity becomes $2k\beta^5+\frac{2d(k\beta^5)}{d\beta}d\beta$, and therefore in respect of the elementary spheroidal layer the semiaxes of whose interior and exterior surfaces are β and $\beta+d\beta$, it is $\frac{2d(k\beta^5)}{d\beta}d\beta$. Let $2\mathrm{F}'(\beta)$ denote the integral of this quantity from $\beta=0$ to $\beta=b$, that is, let $\int\frac{d(k\beta^5)}{d\beta}d\beta=2\mathrm{F}'(\beta)$, and the moment of inertia of the heterogeneous spheroid becomes $\frac{8\pi}{15}\mathrm{F}'(\beta)$. But the moment of the impressed forces is by prop. 2, $\frac{3S}{r^3}\cdot\frac{8\pi}{15}\mathrm{F}(\beta)\sin\theta\cos\theta$, therefore in the case of the heterogeneous spheroid,

$$\phi=\frac{3S}{r^3}\cdot\frac{\mathrm{F}(\beta)}{\mathrm{F}'(\beta)}\sin\theta\cos\theta.$$

Let us assume $\mathrm{K}=\frac{a^2-b^2}{a^2+b^2}$ in the case of the homogeneous spheroid, and $\mathrm{K}=\frac{\mathrm{F}(\beta)}{\mathrm{F}'(\beta)}$ in the case of the heterogeneous spheroid, and we have for both cases

$$\phi=\frac{3S.K}{r^3}\sin\theta\cos\theta.$$

Now to find the place of the pole, and the position of the equator after the small interval of time dt, we must apply the first of the two theorems above premised. If the earth had no diurnal rotation, the sun's force would cause it to revolve about an axis passing through C perpendicular to the meridian PQpq, or perpendicular to the plane of the paper, so as to bring the point Q nearer to the line SC, with a velocity $=\phi$. But the earth is already revolving about the axis Pp, with a velocity $=v$, and in the direction which raises the point q above the plane of the paper. Hence, by theorem 1, the new axis of rotation will be in the plane passing through Pp, perpendicular to the plane of the paper, and after the time dt will make with Pp an angle whose tangent $=\frac{\phi}{v}$, the pole P rising above the plane of the paper; and the new equator will intersect the former in the line Qq, and make with it an angle whose tangent is also $\frac{\phi}{v}$. The effect of the compound motion is thus to twist as it were the equator about the line Qq as an axis, or about that diameter of the equator which lies in the same meridian with the sun, instead of twisting it about the diameter perpendicular to that meridian, as would be the case if the earth had no diurnal motion.

Prop. 4. To find the amount of the solar precession after any given time.

Let AB be the intersection of the plane of the ecliptic, with the surface of sphere whose centre is at the centre of

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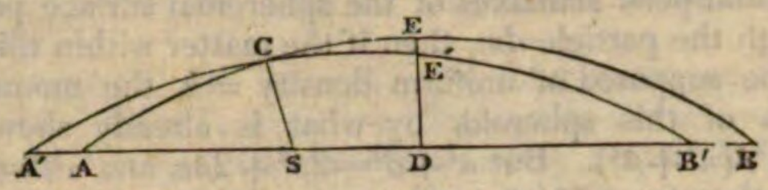
the earth; let ACB be the equator, and S the projection of the sun's place in the ecliptic. Now, the plane of the



equator being always perpendicular to the axis of rotation, when the axis changes its position the equator will also change its position, and the new equator will intersect the former in an angle equal to the deviation of the axis. Let A′CB′ be the new position of the equator, after the infinitely small time *dt*, intersecting the former in C, then the angle ACA′ is the measure of the momentary deviation of the axis, and AA′, which is the amount of variation in the place of the node, is the precession in the time *dt*.

From the known properties of spherical triangles we have sin SAC : sin ACA′ :: sin A′C : sin AA′. But because ACA′ is a very small angle, and AA′ a very small arc, the arcs may be taken instead of the sines; whence, since A′C=AC, the proportion gives $AA'=ACA'\frac{\sin AC}{\sin SAC}$.

But by the last proposition $\tan ACA'=\frac{\phi}{v}=\frac{3S.K}{vr^3}\sin\theta\cos\theta$, therefore, as the small arc may be substituted for its tangent,

$$AA'=\frac{3S.K}{vr^3}\frac{\sin AC}{\sin SAC}\sin\theta\cos\theta.$$

It will now be convenient to express this value of AA′ in terms of the sun's longitude and the obliquity of the ecliptic. Since the equator, as was shewn in the last proposition, is twisted about the diameter which is in the same meridian with the sun, it follows that the line joining S and C is a part of the meridian; whence ACS is a right angle, and SC (the sun's declination)=90°−θ. Let l=AS, (the sun's longitude), and I=SAC, (the obliquity of the ecliptic), then, in the right angled spherical triangle SAC, we have cos SC . cos AC=cos AS, or $\sin\theta\cos AC=\cos l$; and sin SC= sin SAC sin AS, or $\cos\theta=\sin I\sin l$, therefore $\sin\theta\cos\theta=\frac{\sin I\sin l\cos l}{\cos AC}$. Again, in the same triangle we have tan AC=cos SAC tan AS, whence sin AC=cos AC cos I tan l, and (dividing by sin SAC= sin I) $\frac{\sin AC}{\sin SAC}=\frac{\cos AC\cos I\sin l}{\sin I\cos l}$. Substituting these values of $\sin\theta\cos\theta$ and $\frac{\sin AC}{\cos AC}$ in the above value of AA′, we get

$$AA'=\frac{3S.K}{vr^3}\cos I\sin^2 l.$$

This is the solar precession in the element of time *dt*; consequently for a given time T we have

$$\text{solar precession}=\frac{3S.K\cos I}{v}\int\frac{\sin^2 l}{r^3}dt,$$

the integral being taken from t=0 to t=T.

To prepare this expression for integration, r^3 and *dt* must be expressed in terms of l and known quantities. Let a=semiaxis major of the earth's orbit, ϵ=its eccentricity, T=a sidereal year, then r being the radius vector, and *dl* the angle described in the time *dt*, $\frac{1}{2}r^2dl$ is the space passed over by the radius vector in the element of the time, and by Kepler's law of the equable description of areas, we have

$$dt : T :: \tfrac{1}{2}r^2dl : \text{area of orbit.}$$

Now the area of the orbit is $\pi a^2\sqrt{1-\epsilon^2}$, therefore this portion gives $dt=\frac{Tr^2dl}{2\pi a^2\sqrt{1-\epsilon^2}}$. But it is shewn in the article ASTRONOMY, part iii. art. 10, that $T=2\pi\sqrt{a}\div\sqrt{F}$, where F is the attracting force at the mean distance a. But we have assumed S to denote the sun's force at the unit of distance; therefore, the forces being inversely as the squares of the distances, $F=S\div a^2$, whence $T=\frac{2\pi a^{\frac{3}{2}}}{\sqrt{S}}$. From this formula we get $S=\frac{4\pi^2a^3}{T^2}$, and therefore $\frac{S.dt}{r^3}=\frac{2\pi adl}{Tr\sqrt{1-\epsilon^2}}$. Again, assuming λ= longitude of sun's perigee, the polar equation of the ellipse gives $r=\frac{a(1-\epsilon^2)}{1+\epsilon\cos(l-\lambda)}$; whence $\frac{S.dt}{r^3}=\frac{2\pi\{1+\epsilon\cos(l-\lambda)\}dl}{T(1-\epsilon^2)^{\frac{3}{2}}}$, and the above expression becomes

$$\text{solar precession}=\frac{6\pi K\cos I}{Tv(1-\epsilon^2)^{\frac{3}{2}}}\int\sin^2 l\{1+\epsilon\cos(\lambda-l\}dl.$$

The expression under the sign of integration consists of two parts, of which the first $\int\sin^2 l dl=\frac{1}{2}(C+l-\cos l\sin l)$. (See FLUXIONS, art. 153.) The second part, namely $\int\epsilon\sin^2 l\cos(l-\lambda)dl$, when integrated becomes $\epsilon\sin(l-\lambda)-\frac{\epsilon}{2}\sin(l+\lambda)-\frac{\epsilon}{6}\sin(3l-\lambda)$, but by reason of the smallness of ϵ these terms are insensible, and are therefore neglected. Rejecting also the terms in the divisor of the coefficient which are multiplied by ϵ^2, and observing that $\cos l\sin l=\frac{1}{2}\sin 2l$, we obtain, finally,

$$\text{solar precession}=\frac{3\pi K\cos I}{Tv}(C+l-\tfrac{1}{2}\sin 2l).$$

The first term of this expression, which depends upon $C+l$, or on the sun's longitude, is the constant or uniform precession. Its amount in one year is found by supposing l to be increased by 2π, and is consequently $\frac{6\pi^2K\cos I}{Tv}$.

The second is periodic, and being proportional to twice the sine of the sun's longitude, it runs through its changes in half a-year. It is usually regarded as a part of solar nutation, and called *the solar equation of the equinoxes in longitude.*

Prop. 5. To find the diminution of the obliquity of the ecliptic produced by the sun's attraction.

Referring to the last diagram, make AE=EB=90°, and let ED be perpendicular to AB the ecliptic, and meet A′CB′ in E′, then EE′ is the small change in the inclination in the time *dt*. In the triangle ECE′, we have sin EE′ = sin CE sin ECE′. But EE′ being very small, the arc may be taken for the sine, and therefore EE′= sin CE sin ECE′. Now $\sin CE=\cos AC=\frac{\cos l}{\sin\theta}$; and it has been already seen that $\sin ECE'=ACA'=\frac{\phi}{v}=\frac{3S.K}{r^3v}\sin\theta\cos\theta$; therefore $EE'=\frac{3S.K}{r^3v}\cos\theta\cos l$, or since $\cos\theta=\sin I\sin l$, $EE'=\frac{3S.K}{r^3v}\sin I\sin l\cos l$. Multiplying by *dt*, and making the same substitutions as in the last proposition, we have

$$\int EE'dt=\frac{6\pi K}{Tv(1-\epsilon^2)^{\frac{3}{2}}}\sin I\int\sin l\cos l\{1+e\cos(l-\lambda)\}dl,$$

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whence neglecting as before terms multiplied by ϵ, and integrating, there results

$$\int EE'dt = -\frac{3\pi K}{2Tv}\sin I\cos 2l,$$

for the solar nutation in obliquity. This expression, depending on twice the cosine of the sun's longitude, runs through all its changes in half a year; but its greatest value amounts to scarcely half a second, and is consequently altogether insensible to observation.

Prop. 6. To investigate the precessional motion of the equinoxes produced by the moon. Let

M = moon's mass,
E = earth's mass,
I′ = inclination of moon's orbit to the equator,
l' = moon's distance from the intersection of her orbit with the equator,
r' = radius vector of the moon's orbit,
a' = semitransverse axis of moon's orbit,
ϵ' = eccentricity of the lunar orbit,
T′ = sidereal time of revolution.

Then, by following exactly the same reasoning as was pursued in *prop.* 4, there results for the retrograde motion of the points in which the plane of the lunar orbit intersects the plane of the equator (corresponding to the solar precession in *prop.* 4.), the expression

$$\frac{3M.K\cos I'}{v}\int\frac{\sin^2 l'}{r'^3}dt.$$

Now, we have $dt = \frac{T'r'^2dl'}{2\pi a'^2\sqrt{1-\epsilon'^2}}$, and $r' = \frac{a'(1-\epsilon'^2)}{1+\epsilon'\cos(\lambda'-l')}$

therefore $\frac{dt}{r'^3} = \frac{T'\{1+\epsilon'\cos(\lambda'-l')\}dl'}{2\pi a'^3(1-\epsilon'^2)^{\frac{3}{2}}}$. But in the present case $T' = \frac{2\pi a'^{\frac{3}{2}}}{\sqrt{(E+M)}}$ (for the mass of the moon cannot be neglected in comparison of that of the earth, as the mass of the earth is neglected in comparison of that of the sun), hence $\frac{1}{a'^3} = \frac{4\pi^2}{T'^2(E+M)}$. The above expression therefore becomes

$$\frac{6\pi M.K\cos I'}{T'v(E+M)(1-\epsilon'^2)^{\frac{3}{2}}}\int\sin^2 l'\{1+\epsilon'\cos(x-l')dl',\},$$

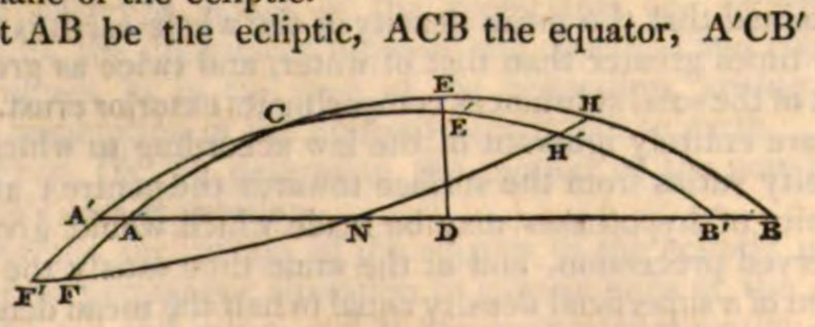
the integral of which (rejecting, as before, terms multiplied by ϵ') gives

$$\frac{3\pi M.K\cos I'}{T'v(E+M)}(C+l'-\tfrac{1}{2}\sin 2l').$$

for the regression of the equator on the plane of the lunar orbit. Suppose l' to be increased by 2π, or a whole circumference, the regression caused by the moon's action in a sidereal revolution becomes $\frac{6\pi^2 M.K\cos I'}{T'v(E+M)}$.

It is now necessary to reduce this retrograde motion to the plane of the ecliptic.

Let AB be the ecliptic, ACB the equator, A′CB′ the



new position of the equator, and FH the plane of the lunar orbit intersecting the new equator in F′ and H′, and the ecliptic in N. The mean effect of the moon's action in the course of a month, if the earth had no motion of rotation, would be to bring the equator nearer the plane of the lunar orbit, causing it to revolve about the line of its intersection with the lunar orbit; therefore by *Theorem* I., the momentary axis of rotation lies in the plane passing through that line and the pole of the equator, and the equator is consequently twisted about the equatorial diameter which is perpendicular to the intersection of the equator and lunar orbit. Hence, FC = CH and F′C = CH′; and since FC + CH = 180°, therefore FC and F′C are quadrantal arcs, and the two triangles CFF and CHH′ are in all respects equal. Now

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sin FC : CF′F :: sin FF′ :: ACA′,
that is, 1 : sin I′ :: FF′ :: ACA′,
and sin CA′A : sin AC :: sin ACA′ :: sin AA′,
that is, sin I : cos AF :: ACA′ :: AA′,
therefore,
sin I : sin I′ cos AF :: FF′ : AA′,
and consequently,

$$AA' = \frac{F'F\sin I'\cos AF}{\sin I}.$$

But AA′ represents the velocity along the ecliptic, and FF′ the velocity along the plane of the moon's orbit, and we have seen that the motion along this plane is $\frac{6\pi^2 K.M\cos I'}{T'v(E+M)}$, in the time T′, or a sidereal revolution. Dividing this by T′, we get the mean velocity in the plane of the orbit in the unit of time; whence $FF' = \frac{6\pi^2 K.M\cos I'}{T'^2v(E+M)}$. For the sake of brevity let $Q = \frac{\pi^2 K.M}{T'^2v(E+M)}$, then FF′ = Q cos I′, and we have

$$AA' = \frac{Q\cos I'\sin I'\cos AF}{\sin I}.$$

We must now express cos I′ sin I′ cos AF, in terms of the obliquity and inclination of the lunar orbit to the ecliptic. Let i = ANF = inclination of moon's orbit to the ecliptic, n = NA, the longitude of the node; then in the triangle ANF, we have by spherical trigonometry,
cos ANF = cos NAF cos NFA + sin NAF sin NFA cos AF,
that is, since NAF = I, NFA = I′,

$$\cos i = \cos I\cos I' + \sin I\sin I'\cos AF,$$

In like manner, in the same triangle,

$$\cos I' = \cos I\cos i + \sin I\sin i\cos n.$$

From these two equations we obtain this other,

$$\cos I'\sin I'\cos AF = \cos I\sin I\cos^2 i - (\cos^2 I - \sin^2 I)\cos i\sin i\cos n - \cos I\sin I\sin^2 i\cos^2 n,$$

which, on substituting in it cos 2I for $\cos^2 I - \sin^2 I$, $\frac{1}{2}\sin 2i$ for $\cos i\sin i$, and $\frac{1}{2}+\frac{1}{2}\cos 2n$ for $\cos^2 n$, becomes

$$\cos I'\sin I'\cos AF = \cos I\sin I(\cos^2 i - \tfrac{1}{2}\sin^2 i) - \tfrac{1}{2}\cos 2I\sin 2i\cos n - \tfrac{1}{2}\cos I\sin I\sin^2 i\cos 2n.$$

Assuming i (the inclination of the moon's orbit) to be constant, which may be done in the present case without sensible error, the only variable in this expression is n, (the longitude of the node), which, on the supposition of i constant, is proportional to the time. Let τ denote the time of a revolution of the node, then for any time t, we have $n = \frac{2\pi t}{\tau}$. On making this substitution in the last equation, we obtain by means of it

$$AA' = Q\left\{\cos I(\cos^2 i - \tfrac{1}{2}\sin i) - \frac{\frac{1}{2}\cos 2I}{\sin I}\sin 2i\cos\frac{2\pi t}{\tau} - \tfrac{1}{2}\cos I\sin^2 i\cos\frac{4\pi t}{\tau}\right\}$$

Now, if we assume y = the regression of the equinoctial points on the ecliptic caused by the lunar action, and sup-

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pose y a function of t, then $AA' = \frac{dy}{dt}$, and the amount of this regression in a given time $= \int \frac{dy}{dt}\, dt$. Multiplying therefore the right hand side of the last equation by dt, and integrating, $\left(\text{observing that } \int \cos\frac{2\pi t}{\tau}\, dt = \frac{\tau}{2\pi}\sin\frac{2\pi t}{\tau}, \right.$ $\left.\text{and } \int \cos\frac{4\pi t}{\tau}\, dt = \frac{\tau}{4\pi}\sin\frac{4\pi t}{\tau}\right)$, we obtain, finally, for the regression of the equinoctial points, or the precessional motion of the equinoxes, produced by the moon in the time t,

$$Q\left\{\cos I\,(\cos^2 i - \tfrac{1}{2}\sin^2 i)t - \frac{\tau}{4\pi}\frac{\cos 2I \sin 2i}{\sin I}\sin\frac{2\pi t}{\tau} - \frac{\tau}{8\pi}\cos I \sin^2 i \sin\frac{4\pi t}{\tau}\right\} + \text{const.}$$

The first term of this expression increases uniformly with the time, and is called the *lunar precession*. The second term, being multiplied by $\sin\frac{2\pi t}{\tau}$, is periodic, and depends on the mean longitude of the moon's ascending node. It is called the *lunar equation of the equinoxes in longitude*. The third term is also periodic, but its numerical value is so small as to be insensible, and it is therefore omitted in the calculation. The lunar precession in a sidereal year is found by substituting T for t in the first term, and we have, therefore,

lunar annual precession $= Q\cos I\,(\cos^2 i - \frac{1}{2}\sin^2 i)T$.

Prop. 7. To find the diminution in the inclination of the equator to the ecliptic produced by the moon's action.

Let AB be bisected in D, and let DE be an arc perpendicular to AB, and meeting A′B′ in E′; then the alteration of obliquity produced by the moon in the time dt is represented by EE′. Now in the triangle CFF′ we have

$$\sin CF' : \sin CFF' :: \sin FF' : \sin FCF',$$

that is, $1 : \sin I' :: FF' : FCF'$;

and in the triangle CEE′,

$$\text{Sin } CE'E : \sin CE :: \sin ECE' : \sin EE'$$

that is, by reason of $CE = AF$ (since $FC = AE = 90°$) and $ECE' = FCF'$

$$1 : \sin AF :: FCF' : EE';$$

whence $EE' = FF' \sin I' \sin AF$. Now it was shewn in the last proposition that $FF' = Q\cos I'$, therefore

$$EE' = Q\cos I' \sin I' \sin AF.$$

To refer this to the ecliptic we have in the triangle NAF,

$$\sin NFA : \sin ANF :: \sin AN : \sin AF$$

which gives the equation

$$\sin I' \sin AF = \sin i \sin n;$$

and, as before we have

$$\cos I' = \cos I \cos i + \sin I \sin i \cos n;$$

whence multiplying the two equations together, and substituting $\frac{1}{2}\sin 2i$ for $\cos i \sin i$, and $\frac{1}{2}\sin 2n$ for $\cos n \sin n$, we get

$$\cos I' \sin I' \sin AF = \tfrac{1}{2}\cos I \sin 2i \sin n + \tfrac{1}{2}\sin I \sin^2 i \sin 2n,$$

and, consequently, writing for n its value $\frac{2\pi t}{\tau}$,

$$EE' = Q\left\{\tfrac{1}{2}\cos I \sin 2i \sin\frac{2\pi t}{\tau} + \tfrac{1}{2}\sin I \sin^2 i \sin\frac{4\pi t}{\tau}\right\}.$$

Multiplying this by dt and integrating, we obtain for the diminution of the inclination, or *lunar nutation in obliquity*

$$-Q\left(\frac{\tau}{4\pi}\cos I \sin 2i \cos\frac{2\pi t}{\tau} + \frac{\tau}{8\pi}\sin I \sin^2 i \cos\frac{4\pi t}{\tau}\right).$$

Both terms of this expression are periodic; but the second is omitted in the calculation, as being too small to be sensible. Hence we have

lunar nutation in obliquity $= -Q \cdot \frac{\tau}{4\pi}\cos I \sin 2i \cos\frac{2\pi t}{\tau}$.

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Prop. 8. To compute the numerical value of the annual precession.

By prop. 4. the solar precession in one year $= \frac{6\pi^2 K \cos I}{Tv}$.

Now Tv is the angle which any point of the earth describes about its axis of rotation in a sidereal year, or 366·26 days, and consequently $= 2\pi \times 366{\cdot}26$. The solar precession therefore becomes $\frac{3\pi K \cos(23° 28')}{366{\cdot}26}$ expressed in parts of the radius. To reduce it to seconds, we have, assuming radius $= 1$, $\pi = 180° = 180 \times 60 \times 60 = 648000$ seconds. Substituting this for π, and computing the above expression by the logarithmic tables we get

solar annual precession $= K \times 4869''$.

By prop. 6, the lunar precession in a sidereal year (on substituting for Q its value) is $\frac{6\pi^2 K \cdot M}{T'^2 v(E+M)}\cos I\,(\cos^2 i - \frac{1}{2}\sin^2 i)T$. But $T'v$ is the angle described by the diurnal rotation of the earth in one sidereal revolution of the moon, or 27·32 days (Astronomy, vol. iii. p. 792), and therefore $= 2\pi \times 27{\cdot}32$. We have also (p. 791), $i = 5°\ 8'\ 47{\cdot}9''$, and, as before, $T = 366{\cdot}26$ days. Now assuming the moon's mass $=$ 1-70th of the earth's mass, $M \div (E+M) = \frac{1}{71}$. By the substitution of these numbers, the lunar annual precession becomes

$$\frac{3\pi \cdot K \times 366{\cdot}26 \times \cos(23° 28') \times \{1 - \frac{3}{2}\sin^2(5° 8' 50'')\}}{27{\cdot}32 \times 27{\cdot}32 \times 71},$$

the calculation of which, reduced to seconds as before, gives

lunar annual precession $= K \times 12176''$.

Adding this to the solar annual precession, we obtain the effect produced by the joint action of the sun and moon, or

luni-solar annual precession $= K \times 17045''$.

It is now necessary to assign a value to the quantity K which depends on the law of the density of the earth. Supposing the earth homogeneous, we have $K = \frac{a^2 - b^2}{a^2 + b^2} = \frac{e}{1-e}$, e being the elipticity $= \frac{1}{301}$, (Figure of the Earth, vol. ix. p. 563), whence $K = \frac{1}{300}$. This value of K gives

luni-solar annual precession $= \frac{17045''}{300} = 56''{\cdot}82$.

The observed quantity is only $50''{\cdot}4$; the difference being occasioned chiefly by the erroneous assumption of the homogeneity of the earth. If the earth be denser towards the centre, (and it is known to be so from other phenomena), the momentum of the protuberant parts will not be so great as if it were equally dense with the interior parts, and the precession will be less. From Cavendish's experiment, and experiments on the attraction of mountains, it has been ascertained that the mean density of the whole earth is about five times greater than that of water, and twice as great as that of the solid substances composing its exterior crust. But we are entirely ignorant of the law according to which the density varies from the surface towards the centre; and an infinity of hypotheses may be made which would give the observed precession, and at the same time satisfy the condition of a superficial density equal to half the mean density.

Prop. 9. To compute the numerical value of the solar and lunar nutation.

The solar nutation consists of two parts. The first is the solar equation of the equinoxes in longitude, or the second term of the expression for the solar precession in prop. 4,

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its value is $\frac{3\pi K}{Tv}\cos I\times\frac{1}{2}\sin 2l$. Substituting $2\pi\times 366{\cdot}26$ for Tv, and multiplying by $\frac{180\times 60\times 60}{\pi}$ to reduce to seconds, the computation gives

1st part of solar nutation $=K\times 387''{\cdot}5\times\sin 2l$.

The second part is the nutation in obliquity, found by prop. 5, the value of which is $\frac{3\pi K}{Tv}\sin I\times\frac{1}{2}\cos 2l$. This being computed in the same manner as the last gives

2d part of solar nutation $=K\times 168''{\cdot}3\times\cos 2l$.

Assuming the earth to be homogeneous, and consequently $K=\frac{1}{300}$, we have for the sum of the two parts

solar nutation $=1''{\cdot}29\sin 2l+0''{\cdot}56\cos 2l$,

both terms being so small as to be insensible to observation.

The lunar nutation is also composed of two parts; the first being the lunar equation of the equinoxes in longitude, or the second term of the expression in prop. 6; and the second the nutation in obliquity found in prop. 7. By prop. 6, the first of these parts is

$$\frac{3\pi K\,.\,M\,.\,\tau}{2T'^2v(E+M)}\,.\,\frac{\cos 2I\sin 2i}{\sin I}\sin\frac{2\pi t}{\tau},$$

which, since $\tau=18{\cdot}6\times 366{\cdot}26$ days, becomes, on substituting for the different quantities their numerical values, and reducing to seconds,

$$K\times\frac{3\times 64800\times 18{\cdot}6\times 366{\cdot}26\times\cos(46^\circ 56)\sin(10^\circ 17' 36)}{2\pi\times(27{\cdot}32)^2\times 2\times 71\sin(23^\circ 28)}\sin\frac{2\pi t}{\tau},$$

whence there is found from computation,

lunar nutation in longitude $=K\times 6093''\times\sin\frac{2\pi t}{\tau}$.

By prop. 7. the lunar nutation in obliquity becomes, on substituting for Q its value, and neglecting the sign,

$$\frac{3\pi K\,.\,M\,.\,\tau}{2T'^2v(E+M)}\,.\,\cos I\times\sin 2i\times\cos\frac{2\pi t}{\tau}.$$

Comparing the coefficient of $\cos\frac{2\pi t}{\tau}$ in this expression with that of $\sin\frac{2\pi t}{\tau}$ in the above, it is obvious that the latter is found by multiplying the former by $\frac{\cos I\sin I}{\cos 2I}=\frac{\sin 2I}{2\cos 2I}$ $=\frac{1}{2}\tan 2I=\frac{1}{2}\tan(46^\circ 56')$. The multiplication gives

lunar nutation in obliquity $=K\times 3260''\cos\frac{2\pi t}{\tau}$.

Assuming that the earth is homogeneous, and consequently $K=\frac{1}{300}$, these two parts added together give

lunar nutation $=20''{\cdot}31\sin\frac{2\pi t}{\tau}+10''{\cdot}88\cos\frac{2\pi t}{\tau}$.

The observed values of the coefficients are $18''{\cdot}36$ and $9''{\cdot}239$, the differences between the observed and computed values, as in the case of the precession, arising from the assumption of the uniform density of the earth.

Prop. 10. To determine the motion of the pole of the earth's axis of rotation.

As the inclination of the equator to the ecliptic undergoes no permanent alteration in consequence of the action of the sun and moon, and as the precessional motion of the equinoxes is proportional to the time, it follows that, abstracting the effects of lunar and solar nutation, the pole of the equator must describe a circle about the pole of the ecliptic, the plane of which is parallel to the ecliptic, and of which the radius is equal to the sine of the obliquity, or $=\sin(23^\circ 28')$. The mean velocity corresponding to the regression of the equinoctial points, is $50''{\cdot}4$ in a year, and consequently the period of a revolution is about 25900 years. Now in order to take account of the lunar nutation (the solar, as has already been remarked, is scarcely sensible), it is only necessary to remark that the absolute velocity of the pole in its small circle, is to the velocity with which the equinoctial points regress in the ecliptic, as the radius of the small circle to the radius of the ecliptic, or as $\sin I:1$. Hence the motion of the pole in the plane of the small circle, is obtained by multiplying the expression in prop. 6, by $\sin I$; and therefore the correction to be applied to the uniform motion of the pole, is the second term of that expression, multiplied by $\sin I$, or $\sin I\times$ lunar equation of the equinoxes in longitude. But by prop. 9, this term $=K\times 6093''\sin\frac{2\pi t}{\tau}$, therefore the corresponding motion of the pole $=K\times 6093''\sin(23^\circ 28')\sin\frac{2\pi t}{\tau}=K\times 2427''\sin\frac{2\pi t}{\tau}$.

With respect to the second part of the nutation, it is obvious that any change of obliquity produces an equal change in the place of the pole on the meridian, and therefore, by the last proposition, the motion of the pole in this direction is $K\times 3260''\cos\frac{2\pi t}{\tau}$. Now let $K\times 2427''=a$, and $K\times 3260''=b$, and let the motion of the pole in the two directions be respectively denoted by x and y, we have then $x=a\sin\frac{2\pi t}{\tau}$, $y=b\cos\frac{2\pi t}{\tau}$; and consequently the equation

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1;$$

which is the equation to an ellipse, and shews that the pole describes a small ellipse about its mean place in the course of a revolution of the nodes, as was discovered by Bradley from observation.

Prop. 11. From the observed values of the precession and nutation, to determine the ratio of the moon's mass to the mass of the earth.

The quantities most accurately determined from observation, from which the moon's mass can be found, are the whole annual precession p $(=50''{\cdot}4)$, and the coefficient of the lunar nutation in obliquity q $(=9''{\cdot}239)$. Let $s=$ the solar annual precession, and $m=$ the lunar annual precession, then $s=p-m$. Now, by prop. 7, $q=Q\frac{\tau}{4\pi}\cos I\sin 2i$, and, by prop. 6, $m=Q\cos I(\cos^2 i-\frac{1}{2}\sin^2 i)T$, whence by eliminating $Q\cos I$, we get

$$m=\frac{q\,.\,4\pi\,.\,T(\cos^2 i-\frac{1}{2}\sin^2 i)}{\tau\sin 2i},$$

and on computing m from the values of T, τ and i above given, we find $m=q\times 3''{\cdot}735=34''{\cdot}51$; therefore, also, $s=p-m=15''{\cdot}89$.

Again, from prop. 4, we have $s=\frac{6\pi^2\,.\,K\cos I}{Tv}$, and from prop. 6, (on substituting for Q its value), $m=\frac{6\pi^2\,.\,K\,.\,M\cos I}{T'^2v(E+M)}(\cos^2 i-\frac{1}{2}\sin^2 i)T$; whence

$$\frac{s}{m}=\frac{T'^2}{T^2(\cos^2 i-\frac{1}{2}\sin^2 i)}\,.\,\frac{E+M}{M}.$$

By computing the coefficient of $(E+M)\div M$, and by means of the values s and m now found, this equation gives

$$\frac{E+M}{M}=81{\cdot}755,$$

whence it follows that the mass of the moon is to the mass of the earth in the ratio of 1 to 80·755.

The phenomena of the precession and nutation, and those

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of the tides, are the only astronomical facts which enable us to determine the moon's mass. From a long series of observations on the tides at the harbour of Brest, Laplace found the ratio of the masses of the moon and earth to be 1 : 75·77.

The regression of the equinoctial points amongst the fixed stars, and consequent precession of the equinoxes, being a motion which, though extremely slow amounting only to a degree in about seventy-two years, increases constantly with the time, was detected at an early period in the history of astronomy, and its rate was determined with considerable accuracy by Hipparchus. Its physical cause was of course not suspected until after the discovery of gravitation; but Newton himself, by a process of reasoning, which, although not quite accurate, affords one of the most remarkable instances of his extraordinary sagacity, (*Principia*, lib. iii. prop. 39), shewed it to be a necessary consequence of the flattened form of the earth. D'Alembert was the first who gave a general and accurate solution of the problem, in his *Recherches sur la Précession des Equinoxes* (1749); and Euler also treated the subject in the *Berlin Memoirs* for the same year. Various solutions of the problem have since been given, amongst which may be mentioned those of Sylvabella and Walmesley in the *Philosophical Transactions* (vols. xlviii. and xlix); that of Simson (*Miscellaneous Tracts*, 1757); that of Frisi in his *Theoria Geometrica Diurni Motûs* (*Opera*, tom. iii.); that of Lagrange in his *Memoir on the Libration of the Moon*, which obtained the prize of the Academy of Sciences of Paris for 1769; that of Landen (*Mathematical Memoirs*, 1780); and that of Vince (*Philosophical Transactions*, 1787.) Of these solutions, that of Frisi deserves to be noticed as perhaps the most perspicuous and elegant. An excellent elementary demonstration is given by Mr. Airy, the present astronomer royal, in his *Mathematical Tracts*, (1826 and 1831) of which we have freely availed ourselves in the present article; but for a complete investigation of the question in all its generality, we must refer the reader to the *Mécanique Céleste*, and still more particularly to a Memoir of Poisson, *Sur le Mouvement de la Terre autour de son Centre de Gravité*, in the *Mémoires de l'Académie Royale des Sciences*, tome vii. 1829. Predestination.

The nutation, as has already been remarked, (see also Astronomy, vol. iii. p. 768), was detected by Bradley, from a comparison of observations which were undertaken with a view to determine the parallax of the fixed stars. Bradley assigned to the coefficient or constant of nutation the value 9″, which till a late period was adopted by most astronomers. Laplace computed its value from theory to be 9″.63; but as this result could only be obtained by having recourse to hypotheses respecting the ellipticity and density of the earth, and also the mass of the moon, which may possibly differ considerably from the truth, it cannot be regarded as of much weight. There are, however, three other determinations of the constant (besides that of Bradley), from observation, which may be supposed to give its value with all the precision that is capable of being attained. The first is that of Von Lindenau, from about 800 observations of Polaris made between the years 1750 and 1815, and consequently including three revolutions of the moon's node; as well as from those made by Bradley, Maskelyne, Bessel, Carlini, Piazzi, and Von Lindenau himself. From these observations he found the value of the constant of nutation to be 8″·97718. The second determination is that of Dr. Brinkley (*Philosophical Transactions*, 1821) deduced from his own observations with the Dublin Mural Circle; and the value which he found was 9″·25. The third determination, and that which has the greatest probability in its favour, is a very recent one by Dr. Robinson of Armagh, undertaken at the instance of the British Association. It is deduced from 11,000 observations made at Greenwich with the mural circle, between the years 1812 and 1834, and embraces more than a complete revolution of the node. The result gives the constant of nutation =9″·23913. (See the *Monthly Notices* of the Royal Astronomical Society for May 1838). S.

PRECORDIA, in *Anatomy*, a general name for the parts situated about the heart, in the forepart of the thorax; as the diaphragm, pericardium, and even the heart itself, with the spleen, lungs, &c.

PREDECESSOR, properly signifies a person who has preceded or gone before another in the same office or employment; in which sense it is distinguished from ancestor.

PREDESTINATION, the supposed decree of God by which he has from all eternity unchangeably appointed whatsoever comes to pass; and has more especially fore-ordained certain individuals of the human race to everlasting happiness, and passed by the rest, fore-ordaining them to everlasting misery. The former of these are called the elect, and the latter are called the reprobate.

This doctrine is the subject of one of the most perplexing controversies that has occurred amongst mankind. But it is not altogether peculiar to the Christian faith. The opinion, that whatever occurs in the world at large, or in the lot of private individuals, is the result of a previous and unalterable arrangement by that Supreme Power which presides over nature, has always been a favourite opinion amongst the vulgar, and has also been believed by many speculative men. Thus, in that beautiful scene in the sixth book of the Iliad, Hector, taking leave of his wife and child, speaks thus:

> Andromache, my soul's far better part,
> Why with untimely sorrows heaves thy heart?
> No hostile hand can antedate my doom,
> Till fate condemns me to the silent tomb.
> Fix'd is the term to all the race of earth,
> And such the hard condition of our birth.
> No force can then resist, no flight can save;
> All sink alike, the fearful and the brave.

The ancient Stoics, Zeno and Chrysippus, whom the Jewish Essenes seem to have followed, asserted the existence of a Deity, who, acting wisely, but necessarily, contrived the general system of the universe; from which, by a series of causes, whatever is now done in it unavoidably results. This series, or concatenation of causes, they held to be necessary in every part; and thought God himself as so much the servant of necessity, and of his own decrees, that he could not have made the smallest object in the world otherwise than it now is, much less was he able to alter any thing.

According to the words of Seneca, *Eadem necessitas et Deos alligat. Irrevocabilis divina pariter atque humana cursus vehit. Ille ipse omnium conditor ac rector scripsit quidem fata sed sequitur. Semper paret, semel jussit.* "The same chain of necessity constrains both gods and men. Its unalterable course regulates divine as well as human things. Even he who wrote the Fates, the Maker and Governor of all things, submits to them. He did but once command, but he always obeys." The stoical fate, however, differs from the Christian predestination in several points. They regarded the divine nature and will as a necessary part of a necessary chain of causes; whereas the Christians consider the Deity as the lord and ruler of the Universe, omnipotent and free, appointing all things according to his pleasure. Being doubtful of the immortality of the soul, the Stoics could have no idea of the doctrine of election and reprobation; nor did they ever doubt their own freedom of will, or power of doing good as well as evil, as we shall presently see the Christian predestinarians have done.

Mahommed introduced into his Koran the doctrine of an absolute predestination of the course of human affairs. He represented life and death, prosperity and adversity, with

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every event that befalls a man in this world, as the result of a previous determination of the one God who rules over all; and he found this opinion the best engine for inspiring his followers with that contempt of danger, which, united to fanatical zeal, has extended the empire of their faith over the fairest portion of the habitable globe.

The controversy concerning predestination first made its appearance in the Christian church about the beginning of the fifth century. Pelagius a British, and Cœlestius an Irish monk, both lived at Rome during that period, and possessed great celebrity on acconnt of their piety and learning. They taught that the opinion is false, which asserts, that human nature is necessarily corrupted by a depravity derived from our first parents. They contended, that men are born at present in a state as pure as that in which Adam was originally created; and that they are not less qualified than he was for fulfiling all righteousness, and for reaching the most sublime eminence of piety and virtue. They maintained that the external grace of God, which is given unto all, and attends the preaching of the gospel, is necessary to call forth the attention and the exertions of men; but that we do not want the assistance of any internal grace to purify the heart, and to give it the first impulse towards what is good. Having fled into Africa on account of the Goths, who at that time (A. D. 410,) invaded Italy, Cœlestius remained at Carthage as a presbyter; but Pelagius went into the East, where he settled, and prospered under the patronage of John bishop of Jerusalem, to whom his sentiments were agreeable. On the contrary, the celebrated Augustin, bishop of Hippo, strenuously asserted the depravity of human nature since the fall of the first man; the necessity of a special interposition of divine grace to enable us to do any one good action; and consequently, that none could obtain salvation excepting those whom God has thought fit to elect, and upon whom he bestows this grace. The dispute was carried on with great zeal. Zozimus, bishop of Rome, decided at first in favour of Pelagius and Cœlestius, whose followers were called *Pelagians;* but he afterwards altered his opinion, and by the activity of Augustin, the council of Ephesus was called, at which the opinion of his antagonists was formally condemned.

In the course of the same century, these opinions assumed a variety of forms and modifications. One party, called *Predestinarians*, carried Augustin's doctrine fully farther than he himself had ventured to do in express words; and asserted, that God had not only predestinated the wicked to punishment, but that he had also decreed that they should commit those very sins on account of which they are hereafter to be punished. Another party moderated the doctrine of Pelagius, and were called *Semipelagians*. Their peculiar opinion is expressed in a different manner by different writers; but all the accounts sufficiently agree. Thus, some represent them as maintaining that inward grace is not necessary to the first beginning of repentance, but only to our progress in virtue. Others say, that they acknowledged the power of grace, but said that faith depends upon ourselves, and good works upon God; and it is agreed upon all hands, that these Semipelagians held that predestination is made upon the foresight of good works. The assistance of St. Augustin, though then far advanced in life, was called in to combat these tenets, and he wrote several treatises upon the subject. In all these he strenuously maintained, that the predestination of the elect was independent of any foresight of their good works, but was according to the good pleasure of God only; and that perseverance comes from God, and not from man. Thereafter the doctrine of St. Augustin, as he is often called, became general. He was the oracle of the schoolmen. They never ventured to differ from him in sentiment; they only pretended to dispute about the true sense of his writings. Predestination.

Almost the whole of the earliest reformers maintained these opinions of St. Augustin. They assumed, under Luther, a more regular and systematic form than they had ever formerly exhibited. But as the Lutherans afterwards abandoned them, they are now known by the name of *Calvinistic Doctrines*, from John Calvin of Geneva. This reformer asserted, that the everlasting condition of mankind in a future world was determined from all eternity by the unchangeable decree of the Deity, arising from his sole good pleasure or free will. Being a man of great ability, industry, and eloquence, Geneva, where he taught, and which was a free state, soon became the resort of all the men of letters belonging to the reformed churches, and was a kind of seminary from which missionaries issued to propagate the Protestant doctrine throughout Europe. Their success was such, that, excepting a small part of Germany, the principles of all the reformed churches are professedly Calvinistic or Predestinarian.

The opponents of the doctrine of predestination amongst the Protestants usually receive the appellation of *Arminians* or *Remonstrants*. They derive the first of these appelations from James Arminius, who, in 1602, was appointed[1] professor of theology at Leyden. He was violently opposed by Gomer his colleague, and died in 1609. After his death, the controversy was conducted with great eagerness on both sides. The Calvinists, however, gradually prevailed. A synod was called at Dort, in 1618, to which the most celebrated divines of different countries were invited. There, in a great measure, by the authority and influence of Maurice prince of Orange, the Arminians were condemned as heretics; for by this time ambitious and powerful men found themselves politically interested in this religious contest. The Arminians presented to this synod a remonstrance, containing a statement of their faith upon the subjects in dispute; and from this they derived the appellation of *Remonstrants*. This statement contained the five following articles. 1. That God from all eternity predestinated those to everlasting salvation whom he foresaw would believe in Christ unto the end of their lives, and predestinated obstinate unbelievers to everlasting punishment. 2. Jesus Christ died for the whole human race, and for every individual of it, but believers alone reap the benefit of his death. 3. No man can produce faith in his mind by his own free-will, but it is necessary that man, who is by nature wicked and unfit for acting or thinking aright, should be regenerated by the grace of the Holy Spirit, imparted by God for Christ's sake. 4. This divine grace constitutes the source, the progress, and the fulfilment, of all that is good in man, but it is not irresistible in its operation. 5. Believers, by the assistance of the Holy Spirit, are abundantly fitted for every good work; but whether it is possible for those who have once been truly such to fall away, and to perish finally, is not clear, and must be better inquired into by searching the Scriptures.

In opposition to these, a counter remonstrance was presented, containing the opinions of the Calvinists, which was approved of by the synod. The substance of it was afterwards adopted, and in nearly the same expressions, into the Confession of Faith compiled by the assembly of divines which met at Westminster, in 1643, and which every clergyman and probationer for the ministry in Scotland is at present required to subscribe previous to his admission. To give as clear and fair an idea as possible to the Calvinistic doctrine upon this head, we transcribe the following passage from that Confession: "God from all eternity did, by the most wise and holy counsel of his own will, freely and unchangeably ordain whatsoever comes to pass; yet so, as thereby neither is God

[1] *Relatio Historica de Origine et Progressu Controversiarum de Prædestinatione* Philippi à Limborch.

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the author of sin, nor is violence offered to the will of the creatures, nor is the liberty or contingencies of second causes taken away, but rather established. Although God knows whatsoever may or can come to pass upon all supposed conditions; yet hath he not decreed any thing because he foresaw it as future, or that which would come to pass upon such conditions. By the decree of God, for the manifestation of his glory, some men and angels are predestinated unto everlasting life, and others are fore-ordained to everlasting death. These angels and men, thus predestinated and fore-ordained, are particularly and unchangeably designed; and their number is so certain and definite, that it cannot be either increased or diminished. Those of mankind that are predestinated unto life, God, before the foundation of the world was laid, according to his eternal and immutable purpose, and the secret counsel and good pleasure of his will, hath chosen, in Christ, unto everlasting glory, out of his mere free grace and love, without any foresight of faith, or good works, or perseverance in either of them, or any other thing in the creature, as conditions or causes moving him thereunto; and all to the praise of his glorious grace. As God hath appointed the elect unto glory, so hath he, by the eternal and most free purpose of his will, fore-ordained all the means thereunto. Wherefore, they who are elected, being fallen in Adam, are redeemed by Christ, are effectually called unto faith in Christ, by his spirit working in due season; are justified, adopted, sanctified, and kept, by his power through faith unto salvation. Neither are any other redeemed by Christ effectually called, justified, adopted, sanctified, and saved, but the elect only. The rest of mankind, God was pleased, according to the unsearchable counsel of his own will, whereby he extendeth or withholdeth mercy as he pleaseth for the glory of his sovereign power over his creatures, to pass by, and to ordain them to dishonour and wrath for their sin, to the praise of his glorious justice."

There are two kinds of Calvinists or Predestinarians, viz. the *Supralapsarians*, who maintained that God did originally and expressly decree the fall of Adam, as a foundation for the display of his justice and mercy; whilst they who maintain that God only *permitted* the fall of Adam, are called *Sublapsarians*, their system of decrees concerning election and reprobation, being as it were, subsequent to that event. But, as Dr. Priestley justly remarks, if we admit the divine prescience, there is not, in fact, any difference between the two schemes; and accordingly that distinction is now seldom mentioned.

Nor was the church of Rome less agitated by the contest about predestination than were the first Protestants. The council of Trent was much perplexed how to settle the matter without giving offence to the Dominicans, who were much attached to the doctrine of St. Augustin, and possessed great influence in the council. After much dispute, the main object came to be, how to contrive such a decree as might give offence to nobody, although it should decide nothing. Upon the whole, however, they seem to have favoured the Semipelagian scheme. Amongst other things, it was determined, that good works are of themselves meritorious to eternal life; but it is added, by way of softening, that it is through the goodness of God, that he makes his own gifts to be merits in us. Catarin revived at that council an opinion of some of the schoolmen, that God chose a small number of persons, such as the blessed virgin, the apostles, and others, whom he was determined to save without any foresight of their good works; and that he also wills that all the rest should be saved, providing for them all necessary means, but they are at liberty to use them or not. This is called the *Baxterian* scheme in England, from one of its promoters there. But at all events, the council of Trent seems to have been extremely anxious that any opinions entertained amongst them concerning predestination might have as little influence as possible upon practical morality. "Let no man," say they, "whilst he remains in this mortal state presume that he is among the number of the elect, and that therefore he cannot sin, or sin without repentance; for it cannot be known who are elected without a special revelation from God." (Sect. 6. c. 13.)

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The Jesuits at first followed the opinion of St. Augustin; but they afterwards forsook it. Molina, one of their order, was the author of what is called the *middle scheme*, or the doctrine of *a grace sufficient for all men*, but subject to the freedom of the human will. Jansenius, a doctor of Louvain, opposed the Jesuits with great vigour, and supported the doctrine of St. Augustin. He wrote in a very artful manner, declaring that he did not presume to state his own sentiments upon the subject. He pretended only to explain and publish the sentiments of that great father of the church St. Augustin. But the Jesuits, in consequence of that inviolable submission to the authority of the pope, which they always maintained, had sufficient interest at Rome to procure the opinion of Jansenius to be condemned there; with this addition subjoined, however, that nothing was thereby intended to be done in prejudice of the doctrine of St. Augustin. This produced an absurd dispute about the pope's infallibility in matters of fact. The Jansenists affirmed, that the pope had made a mistake in condemning the opinions of Jansenius as different from those of St. Augustin; whereas in truth they are the same, and the one cannot be condemned without the other. But the Jesuits affirmed, that the pope is no less infallible in points of fact than he is in questions of faith; and he having decided, that the opinions of Jansenius are different from those of St. Augustin, every good Catholic is bound to believe accordingly that they are different. Some of the very ablest supporters of predestination have appeared amongst the Jansenists, and particularly amongst the gentlemen of Port-Royal.

With regard to Great Britain, the earliest English reformers were in general Sublapsarians, although some of them were Supralapsarians. But the rigid Predestinarians have been gradually declining in number in that church, although they still subscribe the thirty-nine articles of their faith, which are unquestionably Calvinistic. The celebrated Scotch reformer John Knox having been educated at Geneva, established in this country the doctrine of predestination in its strictest form; and it has probably been adhered to with more strictness in Scotland than in any other country of Europe.

PREDETERMINATION, in *Philosophy* and *Theology*, is that concurrence of God which makes men act, and determines them in all their actions, both good and evil, and is called by the schoolmen *physical predetermination* or *premotion*.

PREDICABLE, amongst logicians, denotes a general quality which may be predicated or asserted of several things.

PREDICAMENT, amongst logicians, is the same thing with category.

PREDICATE, in *Logic*, is that which, in a proposition, is affirmed or denied of the subject. In these propositions, *snow is white, and ink is not white;* whiteness is the predicate which is affirmed of snow, and denied of ink.

PREETZ, a town of the Danish dimensions, in Holstein, situated on a lake connected with the Baltic sea. It has a very extensive and rich monastic institution, with some valuable estates belonging to it, though many have been secularised. It is, however, the richest Protestant institution remaining of that kind. The town, with the cloister, contains 400 houses, and 3060 inhabitants.

PRE-EXISTENCE, a priority of being, or the being of one thing before another. Thus a cause, if not in time, is yet in nature pre-existent to its effect. Thus God is pre-existent to the universe, and a human father is pre-existent to his son. The Peripatetics, though they maintained

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the eternity of the world, were likewise dogmatical in their opinion, that the universe was formed, actuated, and governed, by a sovereign intelligence.

The pre-existence of the human soul to its corporeal vehicle had been from time immemorial a prevailing opinion amongst the Asiatic sages, and from them was perhaps transferred by Pythagoras to the philosophy of the Greeks; but his metempsychosis, or transmigration of souls, is too trivial either to be seriously proposed or refuted. Nevertheless, from the sentiments of Socrates concerning the immortality of the soul, delivered in his last interview with his friends, it is obvious that the tenet of pre-existence was a doctrine of the Platonic school. If at any period of life, say these philosophers, you should examine a boy, of how many ideas, of what a number of principles, of what an extent of knowledge will you find him possessed? These without doubt could neither be self-derived nor recently acquired. With what avidity and promptitude does he attain the knowledge of arts and of sciences, which appear entirely new to him? These rapid and successful advances in knowledge can only be the effects of reminiscence, or of a fainter and more indistinct species of recollection. But in all the other operations of memory, we find retrospective impressions attending almost every object or idea which emerges to her view; nor does she ever suggest any thought, or word, or action, without informing us, in a manner equally clear and evident, that those impressions had been made upon our senses, mind, or intellect, on some former occasion. Whoever contemplates her progress, will easily discover, that association is her most faithful and most efficacious auxiliary; and that by joining impression with impression, idea with idea, circumstance with circumstance, in the order of time, of place, of similarity or dissimilarity, she is enabled to accumulate her treasures and enlarge her province even to an indefinite extent. But when intuitive principles, or simple conclusions, are elicited from the puerile understanding by a train of easy questions properly arranged, where is the retrospective act of the memory, by which the boy recognises those truths as having formerly been perceived in his mind? Where are the crowds of the concomitant, antecedent, or subsequent ideas, with which those recollections ought naturally to have been attended? In a word, where is the sense of personal identity, which seems to be absolutely inseparable from every act of memory? This hypothesis, therefore, will not support the notion of pre-existence. After the Christian religion had been considerably diffused, and warmly combated by its philosophical antagonists, the same doctrine was resumed and taught at Alexandria, by Platonic proselytes, not only as a constituent topic of their master's philosophy, but as an answer to those formidable objections which had been deduced from the doctrine of original sin, and from the vices which stain, as well as from the calamities which disturb, human life. Hence they strenuously asserted, that all the human race were either introduced to being prior to Adam, or pre-existent in his person; that they were not, therefore, represented by our first parents, but actually concurred in their crime, and participated in their ruin.

The followers of Origen, and such as entertained the notion of pre-adamites, might argue from the doctrine of pre-existence with some degree of plausibility. For the human beings introduced by them to the theatre of probation had already attained the capacity or dignity of moral agents; as their crime therefore was voluntary, their punishment might be just. But those who believe the whole human race created in Adam to be only pre-existent in their germs or stamina, were even deprived of this miserable subterfuge; for in these "homunculi" we can neither suppose the moral nor rational constitution unfolded. Since, therefore, their degeneracy was not spontaneous, neither could their sufferings be equitable. Should it be said that the evil of original sin was penal, as it extended to our first parents alone, and merely consequential as felt by their posterity, it will be admitted that the distinction between penal and consequential evil may be intelligible in human affairs, where other laws, assortments, and combinations than those which are simply and purely moral, take place. But that a moral government, at one of the most cardinal periods of its administration, should admit gratuitous or consequential evil, seems to us irreconcilable with the attributes and conduct of a wise and just legislator. Consequential evil, taken as such, is misery sustained without demerit, and cannot result from the procedure of wisdom, benignity, and justice, but must flow from necessity, from ignorance, from cruelty, or from caprice, as its only possible sources. But even upon the supposition of those who pretend that man was mature in all his faculties before the commission of original sin, the objections against it will still remain in full force; for it is admitted by all except the Samian sage, that the consciousness of personal identity which was felt in pre-existence, is obliterated in a subsequent state of being.

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Now it may be demanded, whether agents thus resuscitated for punishment have not the same right to murmur and complain as if they had been perfectly innocent, and only created for that dreadful catastrophe? It is upon this principle alone that the effects of punishment can be either exemplary or disciplinary; for how is it possible, that the punishment of beings unconscious of a crime should ever be reconciled either to the justice or beneficence of that intention with which their sufferings are inflicted? Or how can others be supposed to become wise and virtuous by the example of those who are neither acquainted with the origin nor the tendency of their miseries, but have every reason to think themselves afflicted merely for the sake of afflicting? To us it seems clear, that the nature and *rationale* of original sin lie inscrutably veiled and hidden in the bosom of Providence; nor can we, without unpardonable presumption and arrogance, form the most simple conclusion, or attempt the minutest discovery, either different from or extraneous to the clear and obvious sense of revelation. This sense indeed may with propriety be extracted from the whole, or from one passage collated with another; but independently of it, as reason has no premises, she can form no deductions. The boldness and temerity of philosophy, not satisfied with contemplating pre-existence as merely relative to human nature, has dared to try how far it was compatible with the three Persons of the sacred Trinity. The Arians, who allowed the subordinate divinity of our Saviour, believed him pre-existent to all time, and before all worlds; but the Socinians, who esteemed his nature as well as his person merely human, insisted, that before his incarnation he was only pre-existent in the divine idea, not in nature or person. But when it is considered, that children do not begin to deduce instructions from nature and experience, at a period so late as we are apt to imagine; when it is admitted, that their progress, though insensible, may be much more rapid than we apprehend; when the opportunities of sense, the ardour of curiosity, the avidity of memory, and the activity of understanding, are remarked; we need not have recourse to a pre-existent state for our account of the knowledge which young minds discover. It may likewise be added, that moral agents can only be improved and cultivated by moral discipline. Such effects therefore of any state, whether happy or miserable, as are merely mechanical, may be noxious or salutary to the patient, but can never enter into any moral economy as parts of its own administration. Pre-existence, therefore, whether rewarded or punished, without the continued impression of personal identity, affords no solution of original sin.

PREFACE, something introductory to a book, to inform the reader of the design and method observed therein, and generally whatever is necessary to the understanding of a work.

Prefect ‖ Prenomen.

PREFECT, in ancient Rome, one of the chief magistrates who governed in the absence of the kings, consuls, and emperors.

This power was greatest under the emperors. The chief care of the prefect was the government of the city; as taking cognizance of all crimes committed therein or within a hundred miles thereof. He judged capitally and finally, and even presided in the senate. He had also the superintendence of provisions, building, and navigation.

PREJUDICE, or PREJUDGMENT, from *præ* and *judicium*, means a judgment formed beforehand, without examination; the preposition *præ* expressing an anticipation, not so much of time as of knowledge and due attention; and hence the schoolmen have called it *anticipation* and a *preconceived opinion*. See METAPHYSICS.

PRELATE, an ecclesiastic raised to some eminent and superior dignity in the church; as bishops, archbishops, and patriarchs.

PRELIMINARY, in general, denotes something to be examined and determined before an affair can be treated of on its own merits.

PRELUDE, in *Music*, is usually a flourish or irregular air, which a musician plays off hand, to try if his instrument be in tune, and to lead him into the piece to be played.

PREMISES, in *Logic*, an appellation given to the two first propositions of a syllogism.

PREMIUM, or PRÆMIUM, properly signifies a reward or recompense; but it is chiefly used in a mercantile sense for the sum of money given to an insurer, whether of ships, houses, lives, or other subjects.

PREMONSTRANTES, or PRÆMONSTRANTENSES, a religious order of regular canons instituted in 1120, by St. Norbert, and thence called *Norbertines*. The first monastery of this order was built by Norbert in the Isle of France, three leagues to the west of Laon, which he called *Præmonstratum;* and hence the order itself derived its name, though as to the occasion of the denomination, the writers of the order are divided. At first the religious of this order were so very poor, that they had only a single ass, which served to carry the wood they cut down every morning, and was sent to Laon for the bread they purchased. But they soon received so many donations, and built so many monasteries, that in thirty years after the foundation of the order, they had above one hundred abbeys in France and Germany; and in process of time the order so increased, that it had monasteries in all parts of Christendom, amounting to one thousand abbeys, three hundred provostships, a vast number of priories, and five hundred nunneries. But they are now greatly diminished. The rule they followed was that of St. Augustin, with some slight alterations, and an addition of certain severe laws, the authority of which did not long survive their founder. The order was approved by Honorius II. in 1126, and again by several succeeding popes. At first the abstinence from flesh was rigidly observed. In 1245 Innocent IV. complained to a general chapter of its being neglected. In 1288, their general, William, procured leave of Pope Nicholas IV. for those of the order to eat flesh upon journeys. In 1460, Pius II. granted them a general permission to eat meat, excepting from Septuagesima to Easter. The dress of the religious of this order was white, with a scapulary before the cassock.

The Præmonstrantenses, or monks of Premontre, vulgarly called *white canons*, came first into England in the year 1146. Their first monastery, called *New-house*, was erected in Lincolnshire, by Peter de Saulia, and dedicated to St. Martial. In the reign of Edward I. this order had twenty-seven monasteries in England.

PRENOMEN, PRÆNOMEN, amongst the ancient Romans, a name prefixed to the family name, and answering to our Christian name; such as Caius, Lucius, Marcus, and the like.

Prenzlow ‖ Prerogative.

PRENZLOW, a city, the capital of a circle of the same name, in the province of Potsdam in Prussia. It is situated on the river Ucker, and on the north bank of the lake Unteruck. It contains seven Protestant churches, and an institution for education, with nine professors, several hospitals and poor-houses, about nine hundred houses and 10,000 inhabitants, amongst whom is a colony of Frenchmen, established by Protestant refugees. It has considerable manufactures of linen, woollen, and cotton goods, besides tanneries, distilleries and breweries.

PREPARATION, in a general sense, the act of disposing things in such a manner as to render any foreseen event more advantageous or less hurtful according to its nature.

PREPOSITION, in *Grammar*, is one of the parts of speech, being an indeclinable particle which yet serves to govern the nouns that follow it; such as *per*, *pro*, *propter*, through, for, with. Buffier allows it to be only a modificative of a part of speech, serving to circumstantiate a noun.

PRERAU, a city of the Austrian province of Moravia, the capital of a circle of the same name, which extends over 1254 square miles. It comprehends 31 cities and towns, 393 villages, and 54,000 families, consisting of 267,600 persons. The city is situated on the river Betschwa, has a fortress on a neighbouring hill, and contains 460 houses, with 3400 inhabitants.

PREROGATIVE, an exclusive or peculiar privilege.

ROYAL PREROGATIVE, that special pre-eminence which the king has over and above all other persons, and out of the ordinary course of the common law, in right of his regal dignity. It signifies in its etymology (from *præ* and *rogo*) something that is required or demanded before, or in preference to, all others; and hence it follows, that it must be in its nature singular and eccentrical, and that it can only be applied to those rights and capacities which the king alone enjoys in contradistinction to others, and not to those which he enjoys in common with any of his subjects. For if once any one prerogative of the crown could be held in common with the subject, it would cease to be any longer prerogative; and, therefore, Finch lays it down as a maxim, that the prerogative is that law in the case of the king, which is law in no case of the subject.

Prerogative are either *direct* or *incidental*. The *direct* are such positive substantial parts of the royal character and authority, as are rooted in, and spring from, the king's political person, considered merely by itself, without reference to any other extrinsic circumstance; as, the right of sending ambassadors, of creating peers, and of making war or peace. But such prerogatives as are *incidental* bear always a relation to something else, distinct from the king's person, and are indeed only exceptions, in favour of the crown, to those general rules that are established for the rest of the community; such as, that no costs shall be recovered against the king, that the king can never be a joint tenant, and that his debt shall be preferred before a debt to any of his subjects.

These substantive or direct prerogatives may again be divided into three kinds, being such as regard, first, the king's royal *character* or *dignity;* secondly, his royal *authority* or *power;* and, lastly, his royal *income*. These are necessary, to secure reverence to his person, obedience to his commands, and an affluent supply for the ordinary expenses of government; without all of which it is impossible to maintain the executive power in due independence and vigour. Yet, in every branch of this large and extensive dominion, our free constitution has interposed such seasonable checks and restrictions, as may curb it from trampling on those liberties which it was meant to secure and establish. The enormous weight of prerogative, if left to itself, spreads havoc and destruction amongst all the inferior movements; but, when balanced and bridled, as with us, by its

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proper counterpoise, timely and judiciously applied, its operations are then equable and regular; it invigorates the whole machine, and enables every part to answer the end of its construction.

I. Of the royal *dignity*. Under every monarchical establishment, it is necessary to distinguish the prince from his subjects, not only by the outward pomp and decorations of majesty, but also by ascribing to him certain qualities as inherent in his royal capacity, distinct from, and superior to, those of any other individual in the nation. For though a philosophical mind will, says Blackstone, consider the royal person merely as one man appointed by mutual consent to preside over many others, and will pay him that reverence and duty which the principles of society demand; yet the mass of mankind will be apt to grow insolent and refractory, if taught to consider their prince as a man of no greater perfection than themselves. The law therefore ascribes to the king, in his high political character, not only large powers and emoluments, which form his prerogative and revenue, but likewise certain attributes of a great and transcendent nature; by which the people are led to consider him in the light of a superior being, and to pay him that awful respect which may enable him with greater ease to carry on the business of government. This is what we understand by the royal dignity; the several branches of which we shall now proceed to enumerate.

1. And, first, the law ascribes to the king the attribute of *sovereignty*, or pre-eminency.

2. "The law also," according to Blackstone, "ascribes to the king, in his political capacity, absolute *perfection*. 'The king can do no wrong;' which ancient and fundamental maxim,' says he, 'is not to be understood as if every thing transacted by the government was of course just and lawful. It means only two things. The first is, that whatever is exceptionable in the conduct of public affairs, is not to be imputed to the king, nor is he answerable for it personally to his people; for this doctrine would totally destroy that constitutional independence of the crown, which is necessary for the balance of power, in our free and active, and therefore compounded, constitution. And, secondly, it means that the prerogative of the crown extends not to do any injury; it is created for the benefit of the people, and therefore cannot be exerted to their prejudice. The king, moreover," he observes, "is not only incapable of *doing* wrong, but even of *thinking* wrong; he can never mean to do an improper thing: in him is no folly or weakness. And, therefore, if the crown should be induced to grant any franchise or privilege to a subject contrary to reason, or in anywise prejudicial to the commonwealth or a private person, the law will not suppose the king to have meant either an unwise or an injurious action, but declares that the king was deceived in his grant; and thereupon such grant is rendered void, merely upon the foundation of fraud and deception, either by or upon those agents whom the crown has thought proper to employ. For the law will not cast an imputation on that magistrate whom it entrusts with the executive power, as if he was capable of intentionally disregarding his trust; but attributes to mere imposition, to which the most perfect of sublunary beings must still continue liable, those little inadvertencies, which, if charged on the will of the prince, might lessen him in the eyes of his subjects."

But this doctrine has been exposed as ridiculous and absurd, by Lord Abingdon, in his *Dedication to the collective Body of the People of England*. "Let us see," says he, "how these maxims and their comments agree with the constitution, with nature, with reason, with common sense, with experience, with fact, with precedent, and with Sir William Blackstone himself; and whether, by the application of these rules of evidence thereto, it will not be found, that (from the want of attention to that important line of distinction which the constitution has drawn between the *king* of England and the *crown* of England) what was attributed to the *monarchy* has not been given to the *monarch*, what meant for the *kingship* conveyed to the *king*, what designed for the *thing* transferred to the *person*, what intended for *theory* applied to *practice*; and so in consequence, that whilst the premises (of the perfection of the monarchy) be true, the conclusion (that the king can do no wrong) be not false.

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"And, first, in reference to the constitution; to which if this matter be applied (meaning what it expresses, and if it do not it is unworthy of notice), it is subversive of a principle in the constitution, upon which the preservation of the constitution depends; I mean the principle of *resistance*; a principle which, whilst no man will now venture to gainsay, Sir William Blackstone himself admits '*is justifiable to the person of the prince*;' when the being of the state is endangered, and the public voice proclaims such resistance necessary; and thus, by such admission, both disproves the maxim, and oversets his own comment thereupon; for to say that 'the king can do no wrong,' and that 'he is incapable even of thinking wrong,' and then to admit that 'resistance to his person is justifiable, are such jarring contradictions in themselves, that, until reconciled, the necessity of argument is suspended.

"With respect then, in the next place, to the agreement of this maxim, and its comment, with nature, with reason, and with common sense, I should have thought myself sufficiently justified in appealing to every man's own reflection for decision, if I had not been made to understand that nature, reason, and common sense, had nothing to do with either. Sir William Blackstone says, 'That though a philosophical mind will consider the royal person merely as one man appointed by mutual consent to preside over others, and will pay him that reverence and duty which the principles of society demand, yet the mass of mankind will be apt to grow insolent and refractory if taught to consider their prince as a man of no greater perfection than themselves; and therefore the law ascribes to the king, in his high political character, certain attributes of a great and transcendent nature, by which the people are led to consider him in the light of a superior being, and to pay him that awful respect which may enable him with greater ease to carry on the business of government.' So that, in order to govern with greater ease (which, by the bye, is mere assertion without any proof), it is necessary to deceive the mass of mankind, by making them believe not only what a philosophical mind cannot believe, but what it is impossible for any mind to believe; and therefore, in the investigation of this subject, according to Sir William, neither nature, reason, nor common sense, can have any concern.

"It remains to examine in how much this maxim and its comment agree with experience, with fact, with precedent, and with Sir William Blackstone himself. And here it is matter of most curious speculation, to observe a maxim laid down, and which is intended for a rule of government, not only without a single case in support of it, but with a string of cases, that may be carried back to Egbert the first monarch of England, in direct opposition to the doctrine. Who is the man, that, reading the past history of this country, will show us any king that has done no wrong. Who is the reader that will not find that all the wrongs and injuries which the free constitution of this country has hitherto suffered, have been solely derived from the arbitrary measures of our kings? And yet the mass of mankind are to look upon the king as a superior being; and the maxim, that 'the king can do no wrong,' is to remain as an article of belief. But, without pushing this inquiry any farther, let us see what encouragement Sir William Blackstone himself has given for our credulity. After stating the maxim, and presenting us with a most lively picture, 'of our sovereign lord

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thus all perfect and immortal,' what does he make this all-perfection and immortality in the end to come to? His words are those: 'For when King Charles's deluded brother attempted to *enslave* the nation,' (*no wrong this, to be sure*), he found it was beyond his power; the people both *could*, and *did*, resist him; and in consequence of such resistance, obliged him to quit his enterprise and his throne together."[1]

The sum of all is this: That the crown of England and the king of England are distinguishable, and not synonymous terms: that allegiance is due to the crown and through the crown to the king; that the attributes of the crown are sovereignty, perfection, and perpetuity; but that it does not therefore follow that the king can do no wrong. It is indeed to be admitted, that in high respect for the crown, high respect is also due to the wearer of that crown; that is, to the king; but the crown is to be preferred to the king, for the first veneration is due to the constitution. It is likewise *to be supposed* that the king *will* do no wrong; and as, to prevent this, a privy council is appointed by the constitution to assist the king in the execution of the government; so if any wrong be done, 'these men, as Montesquieu expresses it, 'may be examined and punished.'

"But if any future king shall think to screen these evil counsellors from the just vengeance of the people, by becoming his own minister; and in so doing, shall take for his sanction the attribute of perfection, shall trust to the deception of his being a superior being, and cloak himself under the maxim that the king can do no wrong; I say, in such a case, let the appeal already made to the constitution, to nature, to reason, to common sense, to experience, to fact, to precedent, and to Sir William Blackstone himself, suffice, and preclude the necessity of any further remarks from me."

To proceed now to other particulars, The law determines, that in the king there can be no negligence or *laches;* and therefore no delay will bar his right. *Nullum tempus occurrit regi*, is the standing maxim upon all occasions; for the law intends that the king is always busied for the public good, and therefore has not leisure to assert his right within the times limited to subjects. In the king also can be no stain or corruption of blood; for if the heir to the crown were attainted of treason or felony, and afterwards the crown should descend to him, this would purge the attainder *ipso facto*. And therefore, when Henry VII., who as earl of Richmond stood attainted, came to the crown, it was not thought necessary to pass an act of parliament to reverse this attainder; because, as Lord Bacon in his history of that prince informs us, it was agreed that the assumption of the crown had at once purged all attainders. Neither can the king, in judgment of law, as king, ever be a minor or under age; and therefore his royal grants and assents to acts of parliament are good, though he has not in his natural capacity attained the legal age of twenty-one. By a statute, indeed, 28 Henry VIII. c. 17, power was given to future kings to rescind and revoke all acts of parliament that should be made while they were under the age of twenty-four; but this was repealed by the statute 1 Edward VI. c. 11, so far as related to that prince, and both statutes are declared to be determined by 24 Geo. II. c. 24. It hath also been usually thought prudent, when the heir-apparent has been very young, to appoint a protector, guardian, or regent, for a limited time; but the very necessity of such extraordinary provision is sufficient to demonstrate the truth of that maxim of common law, that in the king is no minority; and therefore he hath no legal guardian.

3. A third attribute of the king's majesty is his *perpetuity*. The law ascribes to him, in his political capacity, an absolute immortality. The king never dies. Henry, Edward, or George, may die; but the king survives them all. For, immediately upon the decease of the reigning prince in his natural capacity, his kingship or imperial dignity, by act of law, without any *interregnum* or interval, is vested at once in his heir; who is, *eo instanti*, king to all intents and purposes. And so tender is the law of supposing even a possibility of his death, that his natural dissolution is generally called his *demise*, *dimissio vel regis vel coronæ;* an expression which signifies merely a transfer of property; for, as is observed in Plowden, when we say the demise of the crown, we mean only, that, in consequence of the disunion of the king's body-natural from his body-politic, the kingdom is transferred or demised to his successor, and so the royal dignity remains perpetual. Thus, too, when Edward IV., in the tenth year of his reign, was driven from his throne for a few months by the house of Lancaster, this temporary transfer of his dignity was denominated his *demise;* and all process was held to be discontinued, as upon a natural death of the king.

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II. We are next to consider those branches of the royal prerogative which invest this our sovereign lord with a number of *authorities* and *powers;* in the exertion whereof consists the executive part of government. This is wisely placed in a single hand by the British constitution, for the sake of unanimity, strength, and despatch. Were it placed in many hands, it would be subject to many wills. Many wills, if disunited and drawing different ways, create weakness in a government; and to unite those several wills, and reduce them to one, is a work of more time and delay than the exigencies of state will afford. The king of England is therefore not only the chief, but properly, the sole magistrate of the nation; all others acting by commission from, and in due subordination to him; in like manner as, upon the great revolution in the Roman state, all the powers of the ancient magistracy of the commonwealth were concentred in the new emperor; so that, as Gravina expresses it, *In ejus unius persona veteris reipublicæ, vis atque majestas per cumulatas magistratuum potestates exprimebatur.*

In the exertion of lawful prerogative the king is held to be absolute; that is, so far absolute, that there is no legal authority which can either delay or resist him. He may reject what bills, may make what treaties, may coin what money, may create what peers, may pardon what offences, he pleases; unless where the constitution has expressly, or by evident consequence, laid down some exception or boundary, declaring, that thus far the prerogative shall go and no farther. For otherwise the power of the crown would indeed be but a name and a shadow, insufficient for the ends of government, if, where its jurisdiction is clearly established and allowed, any man or body of men were permitted to disobey it, in the ordinary course of law. We do not now speak of those *extraordinary* recourses to the first principles, which are necessary when the contracts of society are in danger of dissolution, and the law proves too weak a defence against the violence of fraud or oppression. And yet the want of attending to this obvious distinction has occasioned these doctrines, of absolute power in the prince and of national resistance by the people, to be much misunderstood and perverted, by the advocates for slavery on the one hand, and the demagogues of faction on the other. The former, observing the absolute sovereignty and transcendent dominion of the crown laid down, as it certainly is, most strongly and emphatically in our law-books as well as our homilies, have denied that any case can be excepted from so general and positive a rule; forgetting how impossible it is, in any practical system of laws, to point out beforehand those eccentrical remedies, which the sudden emergence of national distress may dictate, and which that alone can justify. On the other hand, over-

[1] *Commentaries*, vol. iv. p. 433.

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zealous republicans, feeling the absurdity of unlimited passive obedience, have fancifully, or sometimes factiously, gone over to the other extreme; and, because resistance is justifiable to the person of the prince when the being of the state is endangered, and the public voice proclaims such resistance necessary, they have therefore allowed to every individual the right of determining this expedience, and of employing private force to resist even private oppression; a doctrine productive of anarchy, and, in consequence, equally fatal to civil liberty as tyranny itself. For civil liberty, rightly understood, consists in protecting the rights of individuals by the united force of society. Society cannot be maintained, and of course can exert no protection, without obedience to some sovereign power; and obedience is an empty name, if every individual has a right to decide how far he himself shall obey.

In the exertion, therefore, of those prerogatives which the law has given him, the king is irresistible and absolute, according to the forms of the constitution. And yet, if the consequence of that exertion be manifestly to the grievance or dishonour of the kingdom, the parliament will call his advisers to a just and severe account. For prerogative consisting, as Mr. Locke has well defined it, in the discretionary power of acting for the public good where the positive laws are silent, if that discretionary power be abused to the public detriment, such prerogative is exerted in an unconstitutional manner. Thus the king may make a treaty with a foreign state, which shall irrevocably bind the nation; and yet, when such treaties have been judged pernicious, impeachments have pursued those ministers by whose agency or advice they were concluded.

The prerogatives of the crown, in the sense under which we are now considering them, respect either this nation's intercourse with foreign nations, or its own domestic government and civil polity.

With regard to *foreign concerns*, the king is the delegate or representative of his people It is impossible that the individuals of a state, in their collective capacity, can transact the affairs of that state with another community equally numerous as themselves. Unanimity must be wanting to their measures, and strength to the execution of their counsels. In the king, therefore, as in a centre, all the rays of his people are united, and form by that union a consistency, splendour, and power, that make him feared and respected by foreign potentates; who would scruple to enter into any engagement, that must afterwards be revised and ratified by a popular assembly. What is done by the royal authority, with regard to foreign powers, is the act of the whole nation: what is done without the king's concurrence, is the act only of private men. And so far is this point carried by our law, that it hath been held, that should all the subjects of England make war with a king in league with the king of England, without the royal assent, such war is no breach of the league. And by the statute 2 Henry V. c. 6, any subject committing acts of hostility upon any nation in league with the king, was declared to be guilty of high treason: and, though that act was repealed by the statute 20 Henry VI. c. 11, so far as relates to the making this offence high treason, yet still it remains a very great offence against the law of nations, and punishable by our laws, either capitally or otherwise, according to the circumstances of the case.

1. The king, therefore, considered as the representative of his people, has the sole power of sending ambassadors to foreign states, and receiving ambassadors at home.

2. It is likewise the king's prerogative to make treaties, leagues, and alliances, with foreign states and princes. For by the law of nations, it is essential to the goodness of a league, that it be made by the sovereign power; and then it is binding upon the whole community: And in Britain the sovereign power, *quoad hoc*, is vested in the person of the king. Whatever contracts, therefore, he engages in, no other power in the kingdom can legally delay, resist, or annul. And yet, lest this plenitude of authority should be abused to the detriment of the public, the constitution (as was hinted before) has here interposed a check, by the means of parliamentary impeachment, for the punishment of such ministers as from criminal motives advise or conclude any treaty, which shall afterwards be judged to derogate from the honour and interest of the nation.

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3. Upon the same principle the sovereign has also the sole prerogative of making war and peace. For it is held by all the writers on the law of nature and nations, that the right of making war, which by nature subsisted in every individual, is given up by all private persons that enter into society, and is vested in the sovereign power: and this right is given up, not only by individuals, but even by the entire body of people that are under the dominion of a sovereign. It would indeed be extremely improper, that any number of subjects should have the power of binding the supreme magistrate, and putting him against his will in a state of war. Whatever hostilities, therefore, may be committed by private citizens, the state ought not to be affected thereby; unless that should justify their proceedings, and thereby become partner in the guilt. And the reason which is given by Grotius, why, according to the law of nations, a denunciation of war ought always to precede the actual commencement of hostilities, is not so much that the enemy may be put upon his guard, (which is matter rather of magnanimity than right), but that it may be certainly clear that the war is not undertaken by private persons, but by the will of the whole community; whose right of willing is in this case transferred to the supreme magistrate by the fundamental laws of society. So that, in order to make a war completely effectual, it is necessary with us in Britain that it be publicly declared and duly proclaimed by the king's authority; and then all parts of both the contending nations, from the highest to the lowest, are bound by it. And wherever the right resides of beginning a national war, there also must reside the right of ending it, or the power of making peace. And the same check of parliamentary impeachment, for improper or inglorious conduct, in beginning, conducting, or concluding a national war, is in general sufficient to restrain the ministers of the crown from a wanton or injurious exertion of this great prerogative.

4. But, as the delay of making war may sometimes be detrimental to individuals who have suffered by depredations from foreign potentates, our laws have in some respects armed the subject with powers to impel the prerogative; by directing the ministers of the crown to issue letters of marque and reprisal upon due demand: the prerogative of granting which is nearly related to, and plainly derived from, that other of making war; this being indeed only an incomplete state of hostilities, and generally ending in a formal denunciation of war. These letters are grantable, by the law of nations, whenever the subjects of one state are oppressed and injured by those of another, and justice is denied by that state to which the oppressor belongs. In this case, letters of marque and reprisal (words in themselves synonymous, and signifying a taking in return) may be obtained, in order to seize the bodies or goods of the subjects of the offending state, until satisfaction be made, wherever they happen to be found. And indeed this custom of reprisals seems dictated by nature herself; for which reason we find in the most ancient times very notable instances of it. But here the necessity is obvious of calling in the sovereign power, to determine when reprisals may be made; else every private sufferer would be a judge in his own cause. In pursuance of which principle, it is with us declared by the statute 4 Hen. V. c. 7, that if any subjects of the realm are oppressed in time of truce by any foreigners, the king will grant marque in due form to all that feel themselves grieved.

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5. Upon exactly the same reason stands the prerogative of granting safe-conducts; without which, by the law of nations, no member of one society has a right to intrude into another. And therefore Puffendorf very justly resolves, that it is left in the power of all states to take such measures about the admission of strangers as they think convenient; those being ever excepted who are driven on the coasts by necessity, or by any cause that deserves pity or compassion. Great tenderness is shown by our laws, not only to foreigners in distress, but with regard also to the admission of strangers who come spontaneously: for so long as their nation continues at peace with ours, and they themselves behave peaceably, they are under the king's protection; though liable to be sent home whenever the king sees occasion. But no subject of a nation at war with us can, by the law of nations, come into the realm, nor can travel himself upon the high seas, or send his goods and merchandise from one place to another, without danger of being seized by our subjects, unless he has letters of safe-conduct; which, by divers ancient statutes, must be granted under the king's great seal and enrolled in chancery, or else they are of no effect; the king being supposed the best judge of such emergencies as may deserve exception from the general law of arms. But passports under the king's sign manual, or licenses from his ambassadors abroad, are now more usually obtained, and are allowed to be of equal validity.

These are the principal prerogatives of the king respecting this nation's intercourse with foreign nations; in all of which he is considered as the delegate or representative of his people. But in domestic affairs, he is considered in a great variety of characters, and from thence there arises an abundant number of other prerogatives.

1. He is a constituent part of the supreme legislative power; and, as such, has the prerogative of rejecting such provisions in parliament as he judges improper to be passed. The expediency of which constitution has before been evinced at large under the article PARLIAMENT. We shall only further remark, that the king is not bound by any act of parliament, unless he be named therein by special and particular words. The most general words that can be devised (any person or persons, bodies politic, or corporate, &c.) affect not him in the least, if they may tend to restrain or diminish any of his rights or interests. For it would be of most mischeivous consequence to the public, if the strength of the executive power were liable to be curtailed, without its own express consent, by constructions and implications of the subject. Yet, where an act of parliament is expressly made for the preservation of public rights and the suppression of public wrongs, and does not interfere with the established rights of the crown, it is said to be binding as well upon the king as upon the subject: and, likewise, the king may take the benefit of any particular act, though he be not especially named.

2. The king is considered, in the next place, as the generalissimo, or the first in military command, within the kingdom. The great end of society is to protect the weakness of individuals by the united strength of the community; and the principal use of government is to direct that united strength in the best and most effectual manner, to answer the end proposed. Monarchical government is allowed to be the fittest of any for this purpose: it follows therefore, from the very end of its institution, that in a monarchy the military power must be trusted in the hands of the prince.

In this capacity, therefore, of general of the kingdom, the king has the sole power of raising and regulating fleets and armies. We are now to consider the prerogative of enlisting and governing them: which indeed was disputed and claimed, contrary to all reason and precedent, by the long parliament of king Charles I.; but, upon the restoration of his son, was solemnly declared by the statute 13 Charles II. c. 6, to be in the king alone: for that the sole supreme government and command of the militia within all his majesty's realms and dominions, and of all forces by sea and land, and of all forts and places of strength, ever was and is the undoubted right of his majesty, and his royal predecessors, kings and queens of England; and that both or either house of parliament cannot, nor ought, to pretend to the same.

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This statute, it is obvious to observe, extends not only to fleets and armies, but also to forts and other places of strength within the realm; the sole prerogative, as well of erecting, as manning and governing of which, belongs to the king in his capacity of general of the kingdom; and all lands were formerly subject to a tax, for building of castles wherever the king thought proper. This was one of the three things, from contributing to the performance of which no lands were exempted, and therefore called by the Anglo-Saxons the *trinoda necessitas; scilicet pontis reparatio, arcis constructio, et expeditio contra hostem.* And this they were called upon to do so often, that, as Sir Edward Coke from M. Paris assures us, there was in the time of Henry II. 1115 castles subsisting in England. The inconveniencies of which, when granted out to private subjects, the lordly barons of those times, were severely felt by the whole kingdom; for, as William of Newburgh remarks, in the reign of king Stephen, *erant in Anglia quodammodo tot reges, vel potius tyranni, quot domini castellorum;* but it was felt by none more sensibly than by two succeeding princes, king John and king Henry III. And therefore, the greatest part of them being demolished in the barons' wars, the kings of after times have been very cautious of suffering them to be rebuilt in a fortified manner: and Sir Edward Coke lays it down, that no subject can build a castle, or house of strength imbattled, or other fortress defensible, without the license of the king; for the danger which might ensue, if every man at his pleasure might do it.

It is partly upon the same, and partly upon a fiscal foundation, to secure his marine revenue, that the king has the prerogative of appointing ports and havens, or such places only, for persons and merchandise to pass into and out of the realm, as he in his wisdom sees proper. By the feudal law, all navigable rivers and havens were computed among the regalia, and were subject to the sovereign of the state. And in England it hath always been held, that the king is lord of the whole shore, and particularly, is the guardian of the ports and havens, which are the inlets and gates of the realm; and therefore, so early as the reign of king John, we find ships seized by the king's officers for putting in at a place that was not a legal port. These legal ports were undoubtedly at first assigned by the crown; since to each of them a court of portmote is incident, the jurisdiction of which must flow from the royal authority. The *great ports* of the sea are also referred to, as well known and established, by statute 4 Hen. IV. c. 20, which prohibits the landing elsewhere under pain of confiscation; and the statute 1 Eliz. c. 11, recites, that the franchise of lading and discharging had been frequently granted by the crown.

But though the king had a power of granting the franchise of havens and ports, yet he had not the power of resumption, or of narrowing and confining their limits when once established; but any person had a right to load or discharge his merchandise in any part of the haven, whereby the revenue of the custom was much impaired and diminished, by fraudulent landings in obscure and private corners. This occasioned the statutes of 1 Eliz. c. 11, and 13 and 14. Car. II. c. 11. § 14, which enable the crown by commission, to ascertain the limits of all ports, and to assign proper wharfs and quays in each port, for the exclusive landing and loading of merchandise.

The erection of beacons, light-houses, and sea-marks, is also a branch of the royal prerogative; whereof the first

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was anciently used in order to alarm the country in case of the approach of an enemy; and all of them are signally useful in guiding and preserving vessels at sea by night as well as by day.

3. Another capacity in which the king is considered in domestic affairs, is as the fountain of justice, and general conservator of the peace of the kingdom.

4. The king is likewise the fountain of honour, of office, and of privilege; and this in a different sense from that in which he is styled the *fountain of justice;* for here he is really the parent of them.

5. Another light in which the laws of England consider the king with regard to domestic concerns, is as the arbiter of commerce. By commerce, we at present mean domestic commerce only; for the king's prerogative with regard to which, see MONEY, WEIGHTS AND MEASURES, &c.

6. The king is, lastly, considered by the laws of England as the head and supreme governor of the national church.

To enter into the reasons upon which this prerogative is founded, is matter rather of divinity than of law. We shall therefore only observe, that by statute 26 Hen. VIII. c. 1, (reciting that the king's majesty justly and rightfully is, and ought to be the supreme head of the church of England; and so had been recognised by the clergy of that kingdom in their convocation) it is enacted, that the king shall be reputed the only supreme head on earth of the church of England; and shall have annexed to the imperial crown of this realm, as well the title and style thereof, as all jurisdictions, authorities, and commodities, to the said dignity of supreme head of the church appertaining. And another statute to the same purport was made, 1 Eliz. c. 1.

In virtue of this authority the king convenes, prorogues, restrains, regulates, and dissolves, all ecclesiastical synods or convocations. This was an inherent prerogative of the crown long before the time of Henry VIII. as appears by the statute 8 Hen. VI. c. 1, and the many authors, both lawyers and historians, vouched by Sir Edward Coke. So that the statute 25 Hen. VIII. c. 19. which restrains the convocation from making or putting in execution any canons repugnant to the king's prerogative, or the laws, customs, and statutes of the realm, was merely declaratory of the old common law: that part of it only being new, which makes the king's royal assent actually necessary to the validity of every canon. The convocation or ecclesiastical synod, in England, differs considerably in its constitution from the synods of other Christian kingdoms: these consisting wholly of bishops; whereas in England the convocation is the miniature of a parliament, wherein the archbishop presides with regal state; the upper house of bishops represents the house of lords; and the lower house, composed of representatives of the several dioceses at large, and of each particular chapter therein, resembles the house of commons with its knights of the shire and burgesses. This constitution is said to be owing to the policy of Edward I. who thereby at one and the same time let in the inferior clergy to the privileges of forming ecclesiastical canons, which before they had not, and also introduced a method of taxing ecclesiastical benefices, by consent of convocation. From this prerogative also, of being the head of the church, arises the king's right of nomination to vacant bishoprics, and certain other ecclesiastical preferments.

PRESAGE, in *Antiquity*, denotes an augury, or sign of some future event; which was chiefly taken from the flight of birds, the entrails of victims, &c.

PRESBURG, a city of the Austrian province of Hither Danube in Hungary, the capital of the circle of the same name, which is more fertile than extensive, and contains about 260,000 inhabitants, in 5 cities, 23 market towns, and 292 villages. The city is on the Danube over which is a long bridge. It is the place in which the emperors of Austria have recently been crowned. It is well built, and contains an imperial palace, a cathedral, several churches and monasteries, an academy and other seminaries, and societies of various kinds for promoting science and literature. It has several manufactories of cloth and cotton, of looking-glasses, cutlery, silk and leather, and much transit and other trade. Its prosperity has kept pace with its population, the latter of which was in 1817, 26,000, and in 1827, 40,733, and it is said to have since increased. Lat. 48. 0. 5. Long. 17. 1. 0. E.

Presbytæ ‖ Presbyterians.

PRESBYTÆ, persons whose eyes are too flat to refract the rays sufficiently, so that unless the object is at some distance, the rays coming from it will pass through the retina before their union, consequently vision is confused; old people are usually the subjects of this disease. In order to remedy, or at least to palliate, this defect, the person should first use glasses which do not magnify, and from them pass gradually to more convex spectacles, which shorten the focus.

PRESBYTER, in the primitive Christian church, an elder, one belonging to the second order of ecclesiastics; the other two being bishops and deacons.

Presbyter, or elder, is a word borrowed from the Greek translation of the Old Testament, where it commonly signifies ruler or governor; it being a note of office and dignity, not of age; and in this sense bishops are sometimes called *presbyters* in the New Testament. The presbyters might baptize, preach, consecrate, and administer the eucharist in the bishop's absence, or in his presence, if he authorised and deputed them; and the bishops did scarcely anything in the government of the church without their advice, consent, and amicable concurrence.

The grand dispute between the followers of Geneva and Roman discipline, is about the sameness and difference of presbyters and bishops at the time of the apostles.

Discriminating principle of the presbyterians.

PRESBYTERIANS, Protestants, so called from their maintaining that the government of the church appointed in the New Testament was by presbyteries, that is, by associations of presbyters or elders, all possessed of equal powers, without any superiority among them either in office or in order.

The presbyterians believe, that the authority of their ministers to preach the gospel, to administer the sacraments of baptism and the Lord's supper, and to feed the flock of Christ, is in no respect inferior to the authority possessed by the ministers of any other church. They oppose the independent scheme of the common rights of Christians by the same arguments which are used for that purpose by the episcopalians, (see EPISCOCACY). They affirm, however, that in the church, as established by Christ and his apostles, there is no order superior to that of presbyters; that all ministers are equal by their commission; that *presbyter* and *bishop*, though different words, are of the same import; and that prelacy or diocesan episcopacy was gradually established upon the primitive practice of making the *moderator* or president of the presbytery a permanent officer.

Scriptural arguments against episcopacy.

These positions they maintain against the episcopalians by the following scriptural arguments. They observe, that the apostles planted churches by ordaining bishops and deacons in every city; that the ministers which in one verse are called bishops, are in the next perhaps denominated presbyters; that we nowhere read in the New Testament of bishops, presbyters, and deacons, in any one church; and that therefore we are under the necessity of concluding *bishop* and *presbyter* to be two names for the same church officer. This is apparent from Peter's exhortation to the *elders* or *presbyters* who were among the Jewish Christians. "The *elders* (presbyters) which are among you I exhort, who am also an *elder*, and a witness of the sufferings of Christ, and also a partaker of the glory that shall be revealed: Feed the flock of God which is among you, taking the *oversight* thereof (ἐπισκοποῦντες, acting as *bishops* thereof,) not by constraint, but willingly; not for filthy lucre, but of

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a ready mind; neither as being LORDS over God's heritage, but being ensamples to the flock."[1] From this passage it is evident, that the presbyters not only fed the flock of Christ, but also governed that flock with episcopal powers; and that the apostle himself, as an officer of the church, was nothing more than a presbyter or elder. The identity of the office of bishop and presbyter is still more apparent from Heb. xiii. 7. 17. and 1 Thess. v. 12; for the bishops are there represented as governing the flock, speaking to them the word of God, watching for their souls, and discharging various offices, which it is impossible for any man to perform to more than one congregation.

Reasons for supposing bishops and presbyters of the same order.

From the last cited text it is evident, that the bishops (*προϊσταμένους*) of the Thessalonian churches had the pastoral care of no more souls than they could hold personal communion with in God's worship; for they were such as all the people were to *know*, *esteem*, and *love*, as those that not only were *over them*, but also "closely laboured among them, and admonished them." But diocesan bishops, whom ordinarily the hundredth part of their flock never hear nor see, cannot be those bishops by whom that flock is admonished, nor can they be, what Peter requires the bishops of the Jewish converts to be, *ensamples to the flock*. It is the opinion of Dr. Hammond, who was a learned divine, and a zealot for episcopacy, that the *elders* whom the apostle James desires[2] the sick to call for, were of the highest permanent order of ecclesiastical officers; but it is self-evident that those elders cannot have been diocesan bishops, otherwise the sick must have been often beyond the reach of the remedy proposed to them.

There is no passage of Scripture on which the episcopalian is more ready to rest his cause, than the alleged episcopacy of Timothy and Titus; of whom the former is said to have been bishop of Ephesus, and the latter bishop of Crete; yet the presbyterian thinks it as clear as the noonday sun, that the presbyters of Ephesus were supreme governors under Christ of the Ephesian churches, at the very time that Timothy is pretended to have been their proper diocesan.

In Acts xx. 17, seq. we read, that "from Miletus Paul sent to Ephesus, and called the elders (presbyters) of the church. And when they were come to him, he said unto them, Ye know, from the first day that I came into Asia, after what manner I have been with you, at all seasons. And now I know that ye all, among whom I have gone preaching the kingdom of God, shall see my face no more. Wherefore I take you to record this day, that I am pure from the blood of all men. For I have not shunned to declare unto you all the counsel of God. Take heed therefore unto yourselves, and to all the flock over which the Holy Ghost hath made you overseers, (*ἐπισκόπους*, *bishops*), to feed the church of God, which he hath purchased with his own blood. For I know this, that after my departure shall grievous wolves enter in among you, not sparing the flock. Also of your ownselves shall men arise, speaking perverse things, to draw away disciples after them. Therefore watch, and remember, that by the space of three years, I ceased not to warn every one night and day with tears. And now, brethren, I recommend you to God, and to the word of his grace," &c.

The pastors of Ephesus of equal authority.

From this passage, it is evident that there was in the city of Ephesus a plurality of pastors of equal authority, without any superior pastor or bishop over them; for the apostle directs his discourse to them all in common, and gives them equal power over the whole flock. Dr. Hammond indeed imagines, that the elders whom Paul called to Miletus were the *bishops of Asia*, and that he sent for them to Ephesus, because that city was the metropolis of the province. But were this opinion well-founded, it is not conceivable that the sacred writer would have called them the elders of the church of *Ephesus*, but the elders of the *church in general*, or the elders of the *churches in Asia*. Besides, it is to be remembered, that the apostle was in such haste to visit Jerusalem, that the sacred historian measures his time by *days;* whereas it must have required several months to call together the bishops or elders of all the cities of Asia; and he might certainly have gone to meet them at Ephesus in less time than would be requisite for their meeting in that city and proceeding thence to him at Miletus. They must therefore have been either the joint pastors of one congregation, or the pastors of different congregations in one city; and as it was thus in Ephesus, so was it in Philippi; for we find the apostle addressing his epistle "to all the saints in Christ Jesus which are at Philippi, with the bishops and deacons." From the passage before us it is likewise plain, that the presbyters of Ephesus had not only the *name* but the whole *power* of bishops given to them by the Holy Ghost; for they are enjoined to do the whole work of bishops, *ποιμαίνειν τὴν ἐκκλησίαν τοῦ Θεοῦ*, which signifies, to *rule* as well as *feed* the church of God. Hence it is evident, that the apostle makes the power of *governing* inseparable from that of *preaching* and *watching;* and that according to him, all who are preachers of God's word, and watchmen of souls, are necessarily rulers or governors of the church, without being accountable for their management to any prelate, but only to their Lord Christ, from whom their power is derived.

Timothy no bishop.

It appears therefore that the apostle Paul left in the church of Ephesus, which he had planted, no other successors to himself than *presbyter-bishops*, or presbyterian ministers, and that he did not devolve his power upon any prelate. Timothy, whom the episcopalians allege to have been the first bishop of Ephesus, was present when this settlement was made;[3] and it is surely not to be supposed, that, had he been their bishop, the apostle would have devolved the whole episcopal power upon the presbyters before his face. If ever there was a season fitter than another for pointing out the duty of this supposed bishop to his diocese, and the duty of his presbyters to him, it was surely when Paul was taking his final leave of them, and discoursing so pathetically concerning the duty of *overseers*, the coming of ravenous wolves, and the consequent hazard of the flock. In this farewell discourse, he tells them that "he had not shunned to declare unto them all the counsel of God." But with what truth could this have been said, if obedience to a diocesan bishop had been any part of their duty either at the time of the apostle's speaking or at any future period? He foresaw that ravenous wolves would enter in among them, and that even some of themselves should arise speaking perverse things; and if, as the Episcopalians allege, diocesan episcopacy was the remedy provided for those evils, is it not strange, passing strange, that the inspired preacher did not foresee that Timothy, who was standing beside him, was destined to fill that important office; or if he did foresee it, that he omitted to recommend him to his future charge, and to give him proper instructions for the discharge of his duty?

Merely an evangelist.

But if Timothy was not bishop of Ephesus, what, it may be asked, was his office in that city? For that he resided there for some time, and was by the apostle invested with authority to ordain and rebuke presbyters, are facts about which all parties are agreed, and which indeed cannot be controverted by any reader of Paul's epistles. To this the presbyterian replies with confidence, that the power which Timothy exercised in the church of Ephesus was that of an evangelist,[4] and not a prelate. But, according to Eusebius, the work of an evangelist was, "to lay the foundations of the faith in barbarous nations, and to constitute among them

[1] 1 Peter v. 1, 2, 3. [2] Chap. v. 14. [3] Acts xx. 5. [4] 2 Tim. iv. 5.

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pastors; after which he passed on to other countries." Accordingly we find, that Timothy was resident for a time at Philippi and Corinth,[1] as well as at Ephesus, and that he had as much authority over those churches as over that of which he is said to have been the fixed bishop. "Now, if Timotheus come, see that he may be with you without fear, for he worketh the work of the Lord, as I also do. Let no man therefore despise him." This text might lead us to suppose, that Timothy was bishop of Corinth as well as of Ephesus; for it affords a more plausible ground than that on which his episcopacy of the latter church is chiefly built. The apostle says, "I besought thee[2] to abide still at Ephesus when I went into Macedonia, that thou mightest charge some that they teach no other doctrine." But had Timothy been the permanent bishop of that city, there would surely have been no necessity for *beseeching* him to abide with his flock. It is likewise to be observed, that the first epistle to Timothy, which alone was written to him during his residence at Ephesus, was of a date prior to Paul's meeting with the elders of that church at Miletus; for in the epistle he hopes to come to him shortly, whereas he tells the elders at Miletus, that they should see his face no more. This being the case, it is evident that Timothy was left by the apostle at Ephesus only to supply his place during his temporary absence at Macedonia, and that he could not possibly have been constituted permanent bishop of that church, since the episcopal powers were afterwards committed to the presbyters by the Holy Ghost in his presence.

Presbyterate the highest permanent office in the church.

The identity of the office of bishop and presbyter being thus clearly established, it follows, that the presbyterate is the highest permanent office in the church, and that every faithful pastor of a flock is successor to the apostles in every thing in which they were to have any successors. In the apostolic office there were indeed some things peculiar and extraordinary, such as their immediate call by Christ, their infallibility, their being witnesses of our Lord's resurrection, and their unlimited jurisdiction over the whole world. These powers and privileges could not be conveyed by imposition of hands to any successors, whether called presbyters or bishops; but as rulers or office-bearers in particular churches, we have the confession of "the very chiefest apostles," Peter and John, that they were nothing more than presbyters or labouring pastors. This being the case, the dispute, which has been so warmly agitated, concerning the validity of presbyterian ordination, may be soon decided; for if the ceremony of ordination be at all essential, it is obvious that such a ceremony performed by presbyters must be valid, as there is no higher order of ecclesiastics in the church by whom it can be performed. Accordingly, we find, that Timothy himself, though said to be a bishop, was ordained by the laying on of the hands of a presbytery. At that ordination indeed St. Paul presided, but he could preside only as *primus in paribus;* for we have seen that, as permanent officers in the church of Christ, the apostles themselves were no more than presbyters. If the apostles' hands were imposed for any other purpose, it must have been to communicate those *charismata* or miraculous gifts of the Holy Spirit, which were then so frequent, but which no modern presbyter or bishop will pretend to give, unless his understanding be clouded by the grossest ignorance, or perverted by the most frantic enthusiasm.

Rise of Episcopacy

But if the office of bishop and presbyter was originally the same, how, it will be asked, came diocesan episcopacy to prevail so universally, as it is confessed to have done, before the conversion of Constantine, and the civil establishment of Christianity in the Roman empire? To give a satisfactory answer to this question is certainly the most arduous task which the advocate for presbytery has to perform; but the difficulties attending this task are not insurmountable.

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From many passages in the New Testament,[3] it is evident, that when the apostles planted churches in different cities, they generally settled more than one pastor in the same church, to feed and govern it with joint authority. The propriety of this constitution is obvious. In those days, when the disciples of Christ were persecuted for their religion, and often obliged to meet in the "night for fear of the Jews," they could not with any degree of prudence assemble in large numbers; and therefore, had there been no more than one pastor in a city, the Christian converts, though, when assembled, they might have amounted to but a small congregation, could not all have enjoyed the benefit of public worship on the same day; at least it is obvious that they could not possibly have assembled for this purpose so often as their want of instruction, and the duty of "breaking of bread and of prayer," required them to meet. It was therefore with great wisdom that the apostles ordained several presbyters in the same church; but as these presbyters would have occasion to meet frequently, and to deliberate on the state of the flock which it was their duty to feed, and over which they had all equal authority, they would be under the necessity of electing one of their own number to be president or *moderator* of the presbytery, that order might be preserved, and all things done with decency. At first there is reason to believe that those presidents held their office no longer than while the presbyteries sat in which they were elected. Among the apostles themselves there was no fixed president. Peter indeed appears to have been most frequently admitted to that honour; but there is one very memorable occasion on record, when James, the Lord's brother, presided in an assembly of apostles, elders, and brethren, held at Jerusalem, to determine the question concerning the necessity of circumcising the Gentiles, and commanding them to keep the law of Moses.

According to Jerom.

Upon this model were the primitive presbyteries formed. They consisted of several presbyters possessed of equal powers, who at their meetings appointed one of their own number to discharge the office of moderator or temporary president; but to this president they gave no prelatical powers or negative voice over the deliberations of his brethren; for, as Jerom informs us, the church was then governed *communi presbyterorum concilio*, "by a common council of presbyters." It appears however that when an apostle, an apostolical man, or an evangelist, fixed his residence in any city, and took upon himself the pastoral care of part of the flock, his co-presbyters, from respect to his singular gifts, made him their constant and fixed moderator. Hence Timothy, during his abode at Ephesus, was moderator of the presbytery; and hence, too, Mark the evangelist, who resided many years in Alexandria, has been called the first bishop of that church, though he appears to have been nothing more than permanent moderator. We advance this upon the authority of Jerom, one of the most learned fathers of the Christian church, who informs us, that upon the death of the evangelist, the presbyters of Alexandria, for more than two hundred years, chose their bishops from their own number, and placed them in the episcopal chair, without dreaming that they ought to be raised to a higher order by a new consecration; "presbyteri unum ex se electum in excelsiori gradu collocatum, episcopum nominabant." As this practice of making the moderator of the presbytery of Alexandria a permanent officer, was thought a good expedient to guard the infant churches against schisms and divisions, those churches gradually adopted it. For, as Jerom tells us, "postquam

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[1] Phil. ii. 19. 1 Cor. iv. 17; xvi. 10, 11. [2] 1 Tim. i. 3. [3] Acts xi. 29; xiij. 1, 2, 3; xv. Tit. i. v. [4] Acts xv.

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unusquisque cos quos baptisaverat, suos putabat esse, non Christi, in toto orbe decretum est, ut unus de presbyteris electus, superponeretur cæteris, ad quem omnis ecclesiæ cura pertineret, et schismatum semina tollerentur."

The advantages which, in displaying his talents and authority, the perpetual president or speaker of any assembly has over his colleagues in office, are so obvious, that when the practice of electing their moderators for life became universal among the presbyteries of the primitive church, it is easy to conceive how ambitious men might so magnify the difficulties and importance of their station, as to introduce the custom of filling it by a new consecration of the bishop elect. But when this was done, diocesan episcopacy, with all its powers and prerogatives, would follow as a matter of course, until "by little and little," as Jerom expresses himself, "the whole pastoral care of the flock was devolved upon one man."

Our limits will not permit us to trace more minutely the rise and progress of this ecclesiastical usurpation, as the Presbyterian calls it; but the reader who wishes for fuller information, after studying the remains of the four first centuries of the Christian church, may consult, "An Inquiry into the Constitution, Discipline, and Worship, of the Primitive Church," written by Lord King, chancellor of England. As an impartial lover of truth, he will do well to consult also a book entitled, "An original Draught of the Primitive Church," which was published as an answer to the Inquiry; and he may read with much advantage to himself, "A Letter from a Parochial Bishop to a Prelatical Gentleman," with "An Apology for the Church of Scotland," both written by Mr. Willison of Dundee, and both evincing considerable learning, and great ingenuity, in their pious author. But during our own age, the presbyterian cause has been most ably maintained by Dr. Campbell, in his "Lectures on Ecclesiastical History," and by Dr. Mitchell, in his "Presbyterian Letters."[1]

The church of Scotland

Of the churches at present formed upon this model, we believe, that without incurring the imputation of national prejudice, we may safely affirm the church of Scotland to be the most efficient. Her mode of worship is simple and solemn; her established faith agreeable to the confessions of most of the other Protestant churches; her judicatories are calculated to maintain the rights of the people; and her pastors are eminently distinguished by their fidelity and zeal. In this respect, a gradual and very perceptible change has taken place in the course of the passing century. We cannot more properly conclude this article than with a short view of her constitution, as being that in which our Presbyterian readers are undoubtedly most interested.

No one is ignorant, that from the first dawn of reformation among us, till the era of the revolution, there was a perpetual struggle between the court and the people for the establishment of an Episcopal or a Presbyterian form of church government. The former model of ecclesiastical polity was patronised by the house of Stewart on account of the support which it gave to the prerogatives of the crown; the latter was the favourite of the majority of the people, perhaps not so much on account of its superior claim to apostolical institution, as because the laity are mixed with the clergy in ecclesiastical judicatories, and the two orders, which under episcopacy are kept so distinct, incorporated into one body. In the Scottish church, every regulation of public worship, every act of discipline, and every ecclesiastical censure, which in other churches flows from the authority of a diocesan bishop, or from a convocation of the clergy, is the joint work of a certain number

governed by clergymen and laymen.

of clergymen and laymen acting together with equal authority, and deciding every question by a majority of votes. The laymen who thus form an essential part of the ecclesiastical courts of Scotland, are called *ruling elders;* and hold the same office, as well as the same name, with those brethren[2] who joined with the apostles and elders at Jerusalem in determining the important question concerning the necessity of imposing upon the Gentile converts the ritual observances of the law of Moses. These lay-elders Paul enjoined Timothy[3] to account worthy of double honour, if they should rule well, and discharge the duties for which they were separated from the multitude of their brethren. In the church of Scotland every parish has several of those lay-elders, who are, or ought to be, grave and serious persons, chosen from among the heads of families, of known orthodoxy, and steady adherence to the worship, discipline, and government of the church. Being solemnly engaged to use their utmost endeavours for the suppression of vice and the cherishing of piety and virtue, and to exercise discipline faithfully and diligently, the minister, in the presence of the congregation, sets them apart to their office by solemn prayer; and concludes the ceremony, which is sometimes called ordination, with exhorting both elders and people to their respective duties.

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The kirk-session.

The kirk-session, which is the lowest ecclesiastical judicatory, consists of the minister and those elders of the congregation. The minister is *ex officio* moderator, but has no negative voice over the decision of the session; nor indeed has he a right to vote at all, unless when the voices of the elders are equal and opposite. He may indeed enter his protest against their sentence, if he think it improper, and appeal to the decision of the presbytery; but this privilege belongs equally to every elder, as well as to every person who may believe himself aggrieved by the proceedings of the session. The deacons, whose proper office is to take care of the poor, may be present in every session, and offer their counsel on all questions that come before it; but except in what relates to the distribution of alms, they have no decisive vote with the minister and elders.

The presbytery.

The next judicatory is the *presbytery*, which consists of all the pastors within a certain district, and one ruling elder from each parish, commissioned by his brethren to represent, in conjunction with the minister, the session of that parish. The presbytery treats of such matters as concern the particular churches within its limits; as the examination, admission, ordination, and censuring of ministers; the licensing of probationers, rebuking of gross or contumacious sinners, the directing of the sentence of excommunication, the deciding upon references and appeals from kirk-sessions, resolving cases of conscience, explaining difficulties in doctrine or discipline; and censuring, according to the word of God, any heresy or erroneous doctrine which hath either been publicly or privately maintained within the limits of its jurisdiction. Partial as we may be thought to our own church, we frankly acknowledge that we cannot altogether approve of that part of her constitution which gives an equal vote, in questions of heresy, to a plain mechanic and his educated pastor. In presbyteries, the only prerogatives which the pastors have over the ruling elders, are the power of ordination, and the privilege of having the moderator chosen from their body.

The provincial synod.

From the judgment of the presbytery, an appeal lies to the provincial synod, which commonly meets twice a-year, and which exercises over the presbyteries within the province a jurisdiction similar to that which is vested in each presbytery over its several kirk-sessions. Of these synods

[1] Presbyterian Letters, addressed to Bishop Skinner of Aberdeen, on his Vindication of Primitive Truth and Order: to which is prefixed, a Preliminary Discourse on the Present State of the Controversy concerning Ecclesiastical Government. By Patrick Mitchell, D.D., Minister of of Remnay, Aberdeenshire. Aberdeen, 1809, 8vo.

[2] Acts xv.

[3] 1 Tim. v. 17.

Prescience. ‖ Prescription.

there are in the church of Scotland fifteen, which are composed of the members of the several presbyteries within the respective provinces which give names to the synods.

The general assembly.

The highest authority in the church is the general assembly, which consists of a certain number of ministers and ruling elders delegated from each presbytery, and of commissioners from the universities and royal burghs. A presbytery in which there are fewer than twelve parishes, sends to the general assembly two ministers and one ruling elder: if it contain between twelve and eighteen ministers, it sends three of these, and one ruling elder: if it contains between eighteen and twenty-four ministers, it sends four ministers and two ruling elders: and of twenty-four ministers, when it contains so many, it sends five with two ruling elders. Every royal burgh sends one ruling elder, and Edinburgh two. Their election must be attested by the kirk-sessions of the respective burghs. Every university sends one commissioner from its own body. The commissioners are annually chosen, six weeks before the meeting of the assembly: and the ruling elders are often men of the first eminence in the kingdom for rank and talents. In this assembly, which meets once a-year, the king presides by his commissioner, who is always a nobleman; but he has no voice in their deliberations. The order of their proceedings is regular, though sometimes the number of members creates a confusion, which the moderator, who is chosen from among the ministers, to be the chairman or speaker of the house, has not sufficient authority to prevent. To the general assembly appeals are brought from all the other ecclesiastical courts of Scotland; and in questions purely religious, no appeal lies from its determinations. In the subordination of these assemblies, parochial, presbyterial, provincial, and national, consists the external order, strength, and stedfastness, of the church of Scotland.

PRESCIENCE, in *Theology*, prevision or foreknowledge; that knowledge which God has of things to come.

PRESCOT, a market-town of the county of Lancaster, in the hundred of West Derby, 198 miles from London, and eight from Liverpool. It is a manufacturing place for making watches, and various kinds of cotton goods. The church is a fine structure, and has a steeple of most elegant appearance, 156 feet high. There is a good market on Thursday. The population was, in 1801, 3465; in 1811, 3678; in 1821, 4468; and in 1831, 5055; but the whole parish, which comprehends fourteen other townships, at the last census, had 28,034 inhabitants.

PRESCRIPTION, in *Law*, denotes a particular mode of establishing a Right or Title.

Prescription, in *Medicine*, signifies much the same with what in common language is called a *receipt*, being a form of direction for the preparation and administration of some compound medicine. These medical receipts are commonly called *formulæ* by physicians; and the term *prescription* is applied to what is written by a physician on seeing his patient, instructing the apothecary what medicines are to be prepared, how they are to be composed, and how administered to the patient. In this sense, a prescription may contain two or more *formulæ*.

These prescriptions are almost always writen in Latin, and are expressed in a peculiar style, which, though well known to physicians and apothecaries, may require the illustration of an example. The following is a specimen of a modern prescription, as it would be written by a physician, according to the nomenclature of the pharmacopœia:

For Mr. Muddleton.

℞. Pulv. Rad. Rhei palmati gr. xxv.
Tartratis Potassæ ʒij.
Tincturæ Sennæ compositæ,
Syrupi Rosæ centifoliæ āā ʒij.
Aquæ Menthæ piperitæ ℥iss.
M.f. *Potio summo mane sumenda.*
Jan. 31, 1839.

From the above example, it will be seen that a prescription, properly so called, contains several circumstances beside the *formulæ* or receipts, as the name of the patient, for whom the prescription is written; the signature of the physician, as J. B. for John Balfour, and the *date of prescribing;* none of which should be omitted, as the prescriptions are carefully preserved by the apothecary, for future reference.

Presence ‖ Presentation.

It may be proper to explain some circumstances respecting the *formula* given in the above prescription. The ℞ with which it commences signifies *recipe* or *take;* and is prefixed to all medical receipts. Then follow the several ingredients of which the medicine is to be composed, with the quantities of each. These quantities are usually marked by peculiar characters or symbols, and the numbers employed are usually the Roman numerals. After the ingredients have been enumerated, and their quantities specified, there follows the title of the medicine, as *Potio* in the present instance, signifying *potion* or *purging draught*, with M. f. prefixed to it, which stand for *misce fiat*, or *misce ut fiat*, mix to make; and lastly, the direction how the medicine is to be taken or administered, *summo mane sumenda*, to be taken early in the morning.

The ingredients of which a formula is composed have been, by writers on medical prescriptions, arranged under four heads: 1. The *basis* of the formula, which in the present instance is the rhubarb, constituting the principal ingredient, on whose action, modified where necessary, the chief success of the medicine, in fulfilling the required indication, is to depend. 2. The *adjuvant* or auxiliary, added to the basis, for the purpose of increasing its power, expediting its action, or rendering it more easily soluble in the juices of the stomach; in the above formula the *tartrate of potash* is the principal adjuvant. 3. The *corrector*, added to the basis, when we wish to moderate or delay its action, to correct some unpleasant or injurious property of it, such as its odour, taste, acrimony, &c., or to prevent it from acting on the body in a different manner from that which the indication requires: thus, in the present formula, the warm *tincture of senna* is added, rather to correct the griping quality of the rhubarb, than to increase its action, and the *syrup of roses* to correct the unpleasant taste of the medicine; and *the essential oil* in the peppermint-water contributes to both these purposes: these, therefore, are to be considered as the correctors. 4. The *constituent*, or that ingredient which serves to reduce the rest into the form which is considered as most convenient for the exhibition of the medicine; in the present case the *peppermint-water* is the constituent, serving to reduce the medicine to the form of a potion or draught.

Medical *formulæ* are either *officinal*, or *extemporaneous;* the former being such as are directed by authority of some public medical college to be kept in the shops of apothecaries, and the preparation of which is described in their *pharmacopœias* or dispensatories; the latter such as are prescribed by the physician or surgeon, as occasion may require.

PRESENCE, a term of relation, used in opposition to absence, and signifying the existence of a person in a certain place.

Present Tense, in *Grammar*, the first tense of a verb, expressing the present time, or that something is now performing; as *scribo*, I write, or am writing.

PRESENTATION, in ecclesiastical law. See Patronage.

Presentation of the Virgin, is a feast of the Catholic church, celebrated on the 21st of November, in memory of the blessed Virgin being presented by her parents in the temple, to be there educated. Emanuel Comnenus, who began to reign in 1143, makes mention of this feast in his Constitutions. Some imagine it to have been established amongst the Greeks in the 11th century; and think they dis-

President, Press.

cover evident proofs of it in some homilies of George of Nicomedia, who lived in the time of Photius. Its institution in the west is ascribed to Gregory XI. in 1372. Others think it was instituted in memory of the ceremony practised amongst the Jews for their newly-born females, and corresponded to the circumcision on the eighth day for males.

PRESENTATION OF OUR LADY also gives the title to three orders of nuns. The first of these was that projected in 1618, by a maid named Joan of Cambray. The habit of the nuns was to be a grey gown of natural wool; but this project was never accomplished. The second was established in France, about the year 1627, by Nicholas Sanguin, bishop of Senlis, and approved by Urban VIII. This order never made any great progress. The third was established in 1664, when Frederick Borromeo, being apostolical visitor in the Valteline, was intreated by some devout maids of Morbegno to allow them to live in community in a retired place; a request which he granted, and erected them into a congregation, under the title of the Congregation of our Lady. They live under the rule of St. Augustin.

PRESIDENT, PRÆSES, is an officer, created or elected to preside over a company or assembly, and is so called in contradistinction to the other members, who are termed *residents*.

LORD PRESIDENT OF THE COUNCIL, is a great officer of the crown, who has precedence next after the lord chancellor and the lord treasurer. The lord president is as ancient as the time of king John, when he was styled *consiliarius capitalis*. His office is to attend upon the king, to propose business at the council-table, and to report to the king the several matters transacted there.

PRESS, in the mechanical arts, is a machine made of iron or wood, and serving to squeeze or compress any body.

The ordinary presses consist of six members, or pieces, viz. two flat smooth planks, between which the things to be pressed are laid; two screws, or worms, fastened to the lower plank, and passing through two holes in the upper; and two nuts, in the form of an S, serving to drive the upper plank, that is moveable against the lower, which is stable, and without motion.

PRESSES *used for expressing liquors*, are of various kinds; some of them being, in most respects, the same with the common presses, excepting that the under plank is perforated with a great number of holes to let the juice expressed run through into a tub, or receiver, underneath.

PRESS *used by Joiners*, to keep close the pieces they have glued, such as panels of wainscot, is very simple. It consists of four members, viz. two screws, and two pieces of wood, four or five inches square, and two or three feet in length, the holes of which at the two ends serve for nuts to the screws.

PRESS *used by Inlayers* resembles the joiner's press, except that the pieces of wood are thicker, and only one of them is moveable; the other, which is in the form of a tressel, being sustained by two legs or pillars, joined to it at each end. This press serves for sawing and cleaving the pieces of wood required in marquetry or inlaid work.

FOUNDER'S PRESS, is a strong square frame, consisting of four pieces of wood, firmly joined together with tenons and otherwise. This press is of various sizes, according to the sizes of the moulds. Two of them are required to each mould, at the two extremities of which they are placed; so that, by driving wooden wedges between the mould and the sides of the presses, the two parts of the mould in which the metal is to be run may be pressed close together.

PRINTING-PRESS. See PRINTING.

ROLLING-PRESS, is a machine used for taking off prints from copper-plates. It is much less complex than that of the letter-press printers.

BINDER'S CUTTING-PRESS, is a machine used equally by book-binders, stationers, and pasteboard-makers, and consists of two large pieces of wood, in the form of cheeks, connected by two strong wooden screws, which, being turned by an iron bar, draw together, or set asunder, the cheeks, as much as is necessary for putting in the books or paper to be cut. The cheeks are placed lengthwise on a wooden stand, in the form of a chest, into which the cuttings fall. Beside the cheeks are two pieces of wood, of the same length with the screws, and which serve to direct the cheeks, and prevent their opening unequally. Upon the cheeks moves the plough, to which the cutting-knife is fastened by a screw; and this knife has its key to dismount it, when it requires to be sharpened.

Pressing Preston.

The plough consists of several parts, and amongst the rest a wooden screw or worm, which, catching within the nuts of the two feet that sustain it on the cheeks, brings the knife to the book or paper, that is fastened in the press between two boards. This screw, which is pretty long, has two directories, which resemble those of the screws of the press. To make the plough slide square and even upon the cheeks, so that the knife may make an equal paring, the foot of the plough where the knife is not fixed, slides in a kind of groove, fastened along one of the cheeks. Lastly, the knife is a piece of steel, six or seven inches in length, flat, thin, and sharp, terminating at one end in a point, like that of a sword, and at the other in a square form, which serves to fasten it to the plough.

PRESS, in the woollen manufactory, is a large wooden machine, serving to press cloths, serges, rateens, &c., thereby to render them smooth and even, and impart to them a gloss.

This machine consists of several members, the principal whereof are the cheeks, the nut, and the worm or screw, accompanied with its bar, which serves to turn it round, and make it descend perpendicularly upon the middle of a thick wooden plank, under which the stuffs to be pressed are placed.

PRESSING, in manufactures, is the violently squeezing a cloth, piece of stuff, or other article, to render it smooth and glossy.

PRESTEIGN, a market-town of the county of Radnor, in South Wales. It is the county town, in which the assizes are held, being 151 miles from London, and 14 from Leominster, and is situated in a rich vale on the river Lug. The county jail is a fine building, and around the town are some pleasant walks and picturesque views. There is a good market, which is held on Saturday. The population was, in 1801, 1152; in 1811, 1211; in 1821, 1387; and in 1831, 1629; but the parish, a part of which is within the English county of Hereford, contained at the last census 3282 inhabitants.

PRESTER JOHN, an appellation formerly given to an emperor of the Tartars, who was overcome and killed by Genghiz Khan. Since that time it has been applied to the Emperor of Abyssinia or Ethiopia; but in Ethiopia itself this name is utterly unknown.

PRESTER, a meteor, consisting of an exhalation thrown downwards from the clouds with such violence, that by the collison it is set on fire. The word is Greek, πρηστηρ, the name of a kind of serpent, called also *dipsas*, to which this meteor is supposed to bear a resemblance. The *prester* differs from the thunderbolt in the manner of its inflammation, and in its burning and breaking every thing it touches with greater violence.

PRESTO, in the Italian music, intimates to perform quickly; and hence, *prestissimo* denotes extreme quickness.

PRESTON, a town of the county of Lancaster, in the hundred of Amounderness, 216 miles from London. It is situated on the river Ribble, and is a corporate place, governed by a mayor, recorder, twelve aldermen, and thirty-six common councilmen; for which purpose it is now divided into six wards, and returns two members to the House of Commons. The town has good wide streets, many fine houses, a very

Preston-pans ‖ Priam.

extensive town-hall and assembly-rooms, a recently built jail, and several charity-schools. It is a place of great manufacturing industry for various kinds of cotton goods, especially cambric muslins; and to the introduction of this trade the town is indebted for its extension in the last forty years. Though the river Ribble is only navigable for small craft, yet it is connected by canals with almost every part of the kingdom, and can, by these means, easily disperse its productions in every direction. It has well-supplied markets on Wednesday, Friday, and Saturday. The two first are well provided with fish for the Roman Catholics, who are very numerous. The population was, in 1801, 11,887; in 1811, 17,065; in 1821, 24,557; and in 1831, 33,112; but, at the last census, the whole parish, consisting of eight other townships, contained 36,336 inhabitants.

PRESTONPANS, a parish and town of Scotland, in Haddingtonshire, about eight miles east from Edinburgh. It has considerable salt-works and manufactures of earthenware, bricks, tiles, &c. It was in the fields to the south of the village that in 1745 Prince Charles Edward defeated the King's troops, under Sir John Cope. The population of the parish in 1831 amounted to 2377.

PRESTWICH, a township of the hundred of Salford, in the county of Lancaster, 184 miles from London, and four from Manchester. It is inhabited chiefly by cotton manufacturers. The population amounted in 1801 to 1811; in 1811 to 2175; in 1821 to 2724; and in 1831 to 2941.

PRETERITE, in *Grammar*, a tense which expresses the time just past, or an action now completely finished, as *scripsi*, I have written, or just finished the act of writing.

PRETERITION, or Pretermission, in *Rhetoric*, is a figure by which, in pretending to pass over a thing untouched, summary mention is nevertheless made of it. Thus, I will not say he is valiant, he is learned, he is just. The most artful praises are those given by way of preterition.

PRETEXT, a colour or motive, whether real or feigned, for doing something.

Toga PRETEXTA, amongst the ancient Romans, a long white gown, with a border of purple round the edges. It was worn by children of quality till the age of puberty; that is, by the boys till the age of seventeen, when they changed it for the *toga virilis*, and by the girls till marriage.

PRETOR, or Prætor, a magistrate amongst the ancient Romans, not unlike our Lord Chief-Justice, or Lord Chancellor, or both in one, being vested with the power of distributing justice amongst the citizens. At first there was only one prætor; but afterwards, another being created, the first or chief one had the title of *prætor urbanus*, or the city prætor, and the other was called *prætor peregrinus*, as being chief judge in all matters relating to foreigners. But, besides these, there were afterwards created many provincial prætors, who were not only judges, but also assisted the consuls in the government of the provinces, and were even invested with the government of provinces themselves.

PRETORIAN Guards, in Roman antiquity, were the guards of the Emperor, who were at length increased to ten thousand. They received this denomination, according to some, from their being stationed at a place called the *prætorium;* and their commander was styled *præfectus prætorii.*

PRETORIUM, or Prætorium, amongst the Romans, denoted the hall or court in which the prætor lived, and wherein also he administered justice.

PRIAM, King of Troy, was the son of Laomedon. He was carried into Greece after the taking of that city by Hercules; but was afterwards ransomed, upon which he obtained the name of *Priam*, a Greek word signifying "ransomed." After his return he rebuilt Ilium, and extended the bounds of the kingdom of Troy, which under his reign became very flourishing. He married Hecuba, the daughter of Cisseus, King of Thrace, by whom he had nineteen children, and amongst the rest Paris, who carried off Helen, and occasioned the ruin of Troy, which is supposed to have been sacked by the Greeks about 1184 before Christ, when Priam was killed by Pyrrhus, the son of Achilles, at the foot of an altar, where he had taken refuge, after a reign of fifty-two years.

Priaman ‖ Price.

PRIAMAN, a town on the south-west coast of Sumatra. In 1685 this was the chief settlement of the East India Company on the island. Long. 99. 43. E. Lat. 0. 36. S.

PRIAPUS, in Pagan worship, the son of Bacchus and Venus, who presided over gardens and the most indecent exhibitions. He was particularly adored at Lampsacus, a city at the mouth of the Hellespont, said to have been the place of his birth; and his image was placed in gardens to defend them from thieves and birds destructive of fruit. He was usually represented naked, with a stern countenance, matted hair, and holding either a wooden sword or sickle in his hand. The sacrifice offered to this obscene deity was the ass; either on account of the natural uncomeliness of this animal, and its propensity to venery, or from the disappointment which Priapus met with on his attempting the chastity of Vesta, whilst that goddess was asleep, when she escaped the intended injury by being awakened in consequence of the braying of old Silenus's ass.

PRICE, Richard, D.D. and LL.D., Fellow of the Royal Society of London, and of the Academy of Sciences, New England, was born at Tynton, in Glamorganshire, on the 22d of February 1723. His father was a dissenting minister at Bridgend, in that county, and died in 1739. At eight years of age he was placed under a Mr. Simmons of Neath; and four years afterwards he was removed to Pentwyn, in Caermarthenshire, where he was placed under the Rev. Samuel Jones, whom he represented as a man of a very enlarged mind, and who first inspired him with liberal sentiments of religion. Having lived as long with him as with Mr. Simmons, he was sent to Mr. Griffith's academy at Talgarth, in Breconshire. In 1740 he lost his mother, upon which he quitted the academy and proceeded to London. Here he was settled at the academy, of which Mr. Eames acted as the principal tutor, under the patronage of his uncle, the Rev. S. Price, who was, for upwards of forty years, co-pastor with Dr. Watts. At the end of four years he left this academy, and resided with Mr. Streatfield, of Stoke Newington, in the quality of domestic chaplain; whilst at the same time he regularly assisted Dr. Chandler at the Old Jewry, and occasionally assisted others. Having lived with Mr. Streatfield nearly thirteen years, he was induced to change his situation, and in the year 1757 married Miss Blundell of Leicestershire. He then settled at Hackney, but being shortly afterwards chosen minister at Newington Green, he lived there until the death of his wife, which took place in 1786, when he returned to Hackney. He was next chosen afternoon-preacher at the meeting-house in Poor Jewry Street; but this he resigned on being elected paster of the Gravel-pit Meeting, Hackney, and afternoon-preacher at Newington Green. These he resigned with a farewell-sermon in February 1791. Shortly afterwards he was attacked with a nervous fever, which disappeared and was succeeded by a disorder in his bladder, which reduced him to such a degree, that, worn out with agony and disease, he died without a groan on the 19th of April 1791. He bequeathed his property to a sister and two nephews.

In morals, Dr. Price's principles were those of Cudworth and Clarke; and by many persons who have themselves adopted a very different theory, he is allowed to have defended these principles with greater ability than any other writer in the English language. In metaphysics he was perhaps too great an admirer of Plato, from whom he has borrowed a doctrine concerning ideas which we confess ourselves unable to comprehend. He was a firm believer in the immateriality of the soul; but, with Dr. Law, the learned bishop of Carlisle, he thought that, from death to the resurrection

Pride. of the body, it remains in a dormant and quiescent state. He contended for its indivisibility, but maintained, at the same time, its extension; which, in the celebrated controversy with Dr. Priestley, furnished the latter with some advantages which his own acuteness would never have obtained. In propagating his political principles, which were republican, he sometimes expressed himself with undue vehemence; and he was a zealous enemy to all religious establishments, which, in his opinion, encroach upon that liberty with which Christ has made us free. His faith respecting the Son of God was what has sometimes been called Low Arianism, and sometimes Semi-Arianism. From a very early age he claimed the privilege of thinking for himself on every subject. His father was a rigid Calvinist, and spared no pains to instil his own theological dogmas into the tender mind of his son; but young Richard would often start his doubts and difficulties, and sometimes incur the old man's displeasure by arguing against his favourite system with an ingenuity that perplexed, and a solidity that could not easily be overturned. He had once the misfortune to be caught reading a volume of Clarke's sermons, which his father, in great wrath, snatched from him, and threw into the fire. Perhaps he could not have taken a more effectual method to make the book a favourite, or to excite the young man's curiosity in regard to the other works of the same author; and it is by no means improbable that this orthodox bigotry contributed more than any other circumstance to lay the foundation of his son's Arianism.

In 1763 or 1764 he was chosen a fellow of the Royal Society, and contributed largely to the transactions of that learned body; in 1769 he received from Aberdeen a diploma creating him Doctor of Divinity; and in 1783 the degree of Doctor of Laws was conferred upon him by the college of Yale in Connecticut. As in the year 1770 he refused an American degree, which had been conveyed to him by Dr. Franklin, his acceptance of one, thirteen years afterwards, can be attributed only to his extravagant attachment to a republican form of government.

To posterity his works will be his monument. They are, 1, A Review of the Principal Questions and Difficulties in Morals, 1758, 8vo.; 2, Dissertations on Providence, 1767, 8vo.; 3, Observations on Reversionary Payments, 1771, 8vo.; 4, Appeal on the National Debt, 1773, 8vo.; 5, Observations on the Nature of Civil Liberty, 1776; 6. On Materialism and Necessity, in a correspondence between Dr. Price and Dr. Priestley, 1779; 7, On Annuities, Assurances, and Population, 1779, 8vo.; 8, On the Population of England, 1780; 9, On the Public Debts, Finances, and Loans, 1783, 8vo.; 10, On Reversionary Payments, 1783, 2 vols.; 11, On the Importance of the American Revolution, 1784; besides Sermons, and a variety of Papers in the *Philosophical Transactions* on Astronomy, and other philosophical subjects.

PRIDE, a term indicating inordinate and unreasonable self-esteem, attended with insolence and rude treatment of others. It is frequently confounded with vanity, and sometimes with dignity; but to the former passion it has no resemblance, and in many circumstances it differs from the latter. Vanity is the parent of loquacious boasting; and the person subject to it, if his pretences be admitted, has no inclination to insult the company. The proud man, on the other hand, is naturally silent, and, wrapt up in his own importance; he seldom speaks except to make his audience feel their inferiority. It is this circumstance which distinguishes pride from dignity. Every man, possesed of great powers of mind, is conscious of them, and feels that he holds a higher rank in the scale of existence than he whose powers are inferior. If he recollect, at the same time, that he has nothing which he did not receive, and that his superiority is owing to the good pleasure of Him who forms his creatures differently, as the potter forms his clay, he will be so far from insulting his inferiors, that, when necessarily in company with them, he will bear with their foibles, and, as far as is proper, make them lose sight of the distance which the laws of God and man have for ever placed between them and him. This condescension, however, if he be a man of dignity, will never lead him to join with them in any mean or unworthy action. He will even excuse in them many things which he would condemn in himself, and will give them his good wishes, after they have forfeited his esteem. Such a character is amiable and respectable; in short, what every man should labour to attain. From the weakness of human nature, however, it is too apt to degenerate into pride. Prideaux.

To a man of great intellectual powers and various erudition, the conversation of ordinary persons affords neither instruction nor amusement; and such conversation, when often repeated, must, from the nature of things, become tedious and irksome. But it requires great command of temper and of manners to prevent uneasiness, long felt, from sometimes betraying itself by external symptoms, such as peevish expressions, a forbidding look, or absence of mind; and these are the infallible indications of contempt for the company, the very worst ingredient in the passion of pride. If this contempt be often excited, it will be formed into a habit; and the proud man will be so much under its influence, as to insult his inferiors, and sometimes even his equals, without forming the resolution to insult either the one or the other. Such a character is hateful to every company, and is so far from indicating true dignity of mind in him to whom it belongs, that it is obviously associated with meanness, and indicates a consciousness of some radical defect. He who possesses real and conspicuous merit has no occasion to depress others for the purpose of raising himself; his superiority will be cheerfully acknowledged; but when a man of undoubted eminence, in one respect, is so swollen with pride as to make him wish to appear great in all respects, he has no other means of enforcing his ill-founded claim, than displaying his acknowledged superiority, with such insolence, as may drive to a distance from him every person by whom he is conscious that, in many instances, he might be more than rivalled. Whoever is proud of knowledge, would do well to consider how much knowledge he wants.

The same observations which we have made on pride of parts, will apply almost to every other species of pride, such as pride of birth, riches, or the like. The peace and order of society require difference of rank, accompanied with different degrees of authority; and he who inherits a title or office from his ancestors, may, without pride, be conscious of his superiority, provided he forget not that such superiority is conferred on families and individuals, not for their own sakes, but for the good of the community. The peer who keeps this circumstance in mind, may maintain his station, and repress the forward petulance of the plebeian, without giving offence to any thinking man; but if he dwell upon his rank with too much complacency, he will, in process of time, be apt to consider himself and his family as superior by nature to those upon whom no title has been conferred, and then his pride will become intolerable. If we could trace our descents, says Seneca, we would find all slaves to come from princes, and all princes from slaves. To be proud of knowledge, is to be blind in the light; to be proud of virtue, is to poison ourselves with the antidote; to be proud of authority, is to make our rise our downfall. The best way to humble a proud man is to neglect him.

PRIDEAUX, Humphry, a very learned clergyman of the Church of England, was born at Padstow, in Cornwall, in 1648. He studied three years at Westminster under Dr. Busby, and was then removed to Christ Church, Oxford. Here, in 1676, he published his *Marmora Oxonensia ex Arundelianis, Seldenianis, aliisque conflata, cum perpetuo Commentario.* This introduced him to the Lord Chancellor Finch, afterwards Earl of Nottingham, who, in 1679, presented him to the Rectory of St. Clement's, near Oxford, and, in 1681, bestowed on him a prebend of Norwich. Some

Priest, Priestley.

years afterwards he was engaged in a controversy with the Catholics at Norwich, concerning the validity of the orders of the Church of England, which produced his book upon that subject. In 1688, he was installed in the archdeaconry of Suffolk, to which he was collated by Dr. Lloyd, then Bishop of Norwich. In 1691, upon the death of Dr. Edward Pococke, the Hebrew professorship at Oxford being vacant, was offered to Dr. Prideaux; but he refused it. In 1697, he published his Life of Mahommed; and, in 1702, he was installed dean of Norwich. In 1710, he was cut for the stone, which interrupted his studies during more than a year. Some time after his return to London, he proceeded with his *Connection of the History of the Old and New Testament*, which he had commenced when he laid aside the design of writing the *History of Appropriations*. He died in 1724.

PRIEST, a person set apart for the performance of sacrifice, and other offices and ceremonies of religion. Before the promulgation of the law of Moses, the first-born of every family, the fathers, the princes, and the kings, were priests. Thus Cain and Abel, Noah, Abraham, Melchizedec, Job, Isaac, and Jacob, offered themselves their own sacrifices. Amongst the Israelites, after their departure from Egypt, the priesthood was confined to one tribe, and it consisted of three orders; the high priest, priests, and Levites. The priesthood was made hereditary in the family of Aaron, and the first-born of the oldest branch of that family, if he had no legal blemish, was always the high priest. This divine appointment was observed with considerable accuracy until the Jews fell under the dominion of the Romans, and had their faith corrupted by a false philosophy. Then, indeed, the high priesthood was sometimes set up to sale, and instead of continuing for life, as it ought to have done, it seems, from some passages in the New Testament, to have been nothing more than an annual office. There is sufficient reason to believe, however, that it was never disposed of except to some descendant of Aaron, capable of filling it, if the older branches were extinct. In the time of David, the inferior priests were divided into twenty-four companies, who were required to serve in rotation, each company by itself, for a week. The order in which the several courses were to serve was determined by lot; and each course was, in all succeeding ages, called by the name of its original chiefs.

All nations have had their priests. The pagans had priests of Jupiter, Mars, Bacchus, Hercules, Osiris, Isis, and other divinities; and some deities had also priestesses. The Mahommedans have priests of different orders, called scheiks and muftis; and the Indians and Chinese have their Brahmins and Bonzes.

It has been very much disputed, whether, in the Christian church, there be any such officer as a priest, in the proper sense of the word. The Church of Rome, which holds the propitiatory sacrifice of the mass, has, of course, her proper priesthood. In the Church of England, the word priest is retained to denote the second order in her hierarchy, but with very different significations, according to the different opinions entertained of the Lord's supper. Some few of her divines, of great learning, and of undoubted Protestantism, maintain that the Lord's supper is a commemorative and eucharistical sacrifice, and consider all who are authorised to administer that sacrament as, in the strictest sense, priests. Others hold the Lord's supper to be a feast upon the sacrifice once offered on the cross; and these, too, must consider themselves as clothed with some kind of priesthood. Great numbers, however, of the English clergy, perhaps the majority, agree, with the Church of Scotland, in maintaining that the Lord's supper is a rite of no other moral import, than the mere commemoration of the death of Christ. These, therefore, cannot consider themselves as priests in the rigid sense of the word, but only as presbyters, or, in other words, elders.

PRIESTLEY, Joseph, LL.D. and F. R. S., a natural philosopher and theologian, was born upon the 24th of March 1773, at Field-head, in the parish of Bristall, in the west riding of Yorkshire. His father was a cloth-manufacturer, and both his parents were respectable Calvinistic dissenters. A strong desire of reading was one of the first passions which this philosopher exhibited, and which probably induced his parents and friends to change their mind respecting his destination, and, instead of bringing him up as a tradesman, to qualify him for some learned profession. He acquired a knowledge of Hebrew, Greek, and Latin, in the school of an eminent teacher at Bartley; and, at the age of nineteen, he became a theological student in the academy of Daventry. When about the age of twenty-two, he was made choice of as assistant minister to the Independent congregation of Needham Market, in Suffolk. Having resided at Needham for about three years, he received an invitation to become pastor of a small flock at Namptwitch, in Cheshire, which he accepted. Here he opened a day school, in the management of which he displayed that turn for research, and that spirit of improvement, which were afterwards destined to form such prominent features in his character. His reputation as a man of extraordinary talents and diligent inquiry, soon spread amongst his professional brethren; and when Dr. Aitken was chosen to succeed the reverend Dr. Taylor as professor of divinity at Warrington, the vacant department of belles lettres was assigned to Mr. Priestley. Priestley.

His literary career may probably be said to have commenced at Warrington; and the extent, as well as the originality of his pursuits, were soon announced to the world by a variety of valuable publications. Much of his attention about this period was taken up with general politics, on which he delivered a number of lectures. Although it was reasonable to think that his time would be sufficiently occupied by his academical and literary employments, yet his unwearied activity and industry found means to accomplish the first great work in philosophy which laid a foundation for his future fame.

Having long amused himself with an electrical machine, and felt himself interested in the progress of discovery in that branch of physics, he undertook a history of electricity, with an account of its present state. This work made its first appearance at Warrington in the year 1767, and was so well received by the learned world, that it went through a fifth edition in quarto, in the year 1794. It is justly deemed a valuable performance, and its original experiments are allowed to be very ingenious.

About the year 1768, he was chosen as pastor of a large and respectable congregation of Protestant dissenters at Leeds, which led him to give a very large share of his attention to theological subjects. His mind is said to have been from childhood strongly impressed with sentiments of piety and devotion; and although he changed most of those religious sentiments in which he had been instructed, for such as he regarded more rational and consistent with truth, his piety and devotion never deserted him. He was at the head of the moderate Unitarians, whose leading tenet is the proper humanity of Christ; confining every species of religious worship and adoration to the one Supreme Being. Some, we believe, have charged him with a design to subvert the Christian religion; but, since zeal for Christianity, as a divine dispensation, and the most valuable of all gifts bestowed upon the human race, was his ruling passion, such an imputation cannot, in fairness, be admitted.

His *History and Present State of Discoveries relating to Vision, Light, and Colours*, appeared in 1772, in two volumes quarto. This is allowed to be a performance of great merit and lucid arrangement; but it did not bring him such a large share of popularity as his *History of Electricity*, because it is probable that he was scarcely qualified to explain the more abstruse parts of the science. In the year

Priestley. 1770, he quitted the town of Leeds for a situation entirely different from that which he had held there. His philosophical writings and the recommendation of Dr. Price had made him favourably known to the Earl of Shelburne, who held out to him such advantageous proposals for residing with him, that a regard for his family did not permit him to reject them. The domestic tuition of Lord Shelburne's sons having been previously committed to a man of merit, they received no instructions from Dr. Priestley further than some courses of experimental philosophy. He also attended his Lordship in a visit to Paris, where he had an opportunity of seeing some of the most celebrated men of science in that country, whom he astonished by asserting a firm belief in revealed religion, which had been presented to their minds in such colours, that they thought no man of sense could hesitate in rejecting it as an idle fable.

In the year 1775, he published his *Examination* of Dr. Reid on the Human Mind; Dr. Beattie on the Nature and Immutability of Truth; and Dr. Oswald's Appeal to Common Sense. The design of this volume was to refute the doctrine of Common Sense, said to be employed as the test of truth by the metaphysicians of Scotland. He never intentionally misrepresented either the arguments or the purposes of an opponent; but he measured the respect with which he treated him by that which he conceived for him in his own mind. In the year 1777, he published his disquisitions relating to *Matter and Spirit*, in which he gave a history of the philosophical doctrine respecting the soul, and openly supported the material system, which makes it homogeneous with the body. This subjected him to more odium than any of his other productions. As he materialized spirit so he in some measure spiritualized matter, by assigning to it penetrability and several other subtle qualities. About the same period he became the champion of philosophical necessity; a doctrine not less obnoxious to many than the former, on account of its supposed, or rather inevitable, effects on morality. So astonishing was the versatility of his mind, that he at the same time carried on that course of discovery concerning aeriform bodies, which has rendered his name so illustrious amongst philosophical chemists. A second volume was published in 1775, and a third in 1777. Some of his most memorable discoveries were those of nitrous and dephlogisticated or pure air; of the restoration of vitiated air by vegetation; of the influence of light on vegetables; and of the effects of respiration on the blood.

The name of Priestley was by these means spread throughout all the countries of Europe, and honours were heaped upon him by scientific bodies in various parts. The term of his engagement with Lord Shelburne having expired, Dr. Priestley found himself at liberty to choose a new situation, and retired with a pension for life of L.150 a-year. He chose the vicinity of the populous town of Birmingham, which was then the residence of several men of science, such as Watt, Withering, Bolton, and Keir, whose names are well known to the public. Here he was invited to become pastor of a dissenting congregation, an offer which he accepted about the latter end of the year 1780. Soon after this appeared his Letters to Bishop Newcome, *On the Duration of Christ's Ministry*, and his *History of the Corruptions of Christianity*, works which were afterwards followed by his *History of Early Opinions*. He displayed his attachment to freedom by his *Essay on the First Principles of Government*, and by an anonymous pamphlet on the *State of Public Liberty* in this country; and he evinced a warm interest in the cause of America at the time of its unfortunate quarrel with the mother country.

On the 14th of July, 1791, the celebration of the anniversary of the destruction of the Bastille, by a public dinner, at which Dr. Priestley was not present, gave the signal for those riots which have brought lasting disgrace on the town of Birmingham, and in some degree upon the national character. Amidst the conflagration of places of worship and of private dwellings, Dr. Priestley was the great object of popular rage; his house, library, manuscripts, and apparatus, were given as a prey to the flames; he was hunted like a criminal, and experienced not only the furious outrages of a mob, but the most unhandsome treatment from some who ought to have supported the character of gentlemen and friends of good order. He now lay under a load of public odium and suspicion, and, besides, he was constantly harassed by the petty malignity of bigotry. It was not to be wondered at, therefore, that he looked for an asylum in a country to which he had always shewn a friendly attachment, and which, he supposed, was in full possession of all the blessings of civil and religious liberty. In the year 1794, he took leave of his native country, and embarked for North America. He took up his residence in Northumberland, a town in the interior of the state of Pennsylvania, which he selected on account of the purchase of landed property in its neighbourhood; otherwise its remoteness from the sea-ports, its want of many of the comforts of life, and of all the helps to scientific pursuit, rendered it a peculiarly undesirable abode for one of Dr. Priestley's habits and employments. The loss of his amiable wife, and of a most promising son, as well as repeated attacks of disease, severely tried the fortitude and resignation of this ill-fated philosopher. Priestley.

In America he was received with general respect, and the angry contests of party were not able wholly to deprive him of the esteem due to his character. He was heard as a preacher by some of the most distinguished members of Congress; and he was offered, but declined, the place of chemical professor of Philadelphia. It became his great object to enable himself, in his retirement at Northumberland, to renew that course of philosophical experiment, and especially that train of theological writing, which had occupied so many of the best years of his life. By numerous experiments on the constitution of airs, he became more and more fixed in his belief of the phlogistic theory, and in his opposition to the new French chemical system, of which he lived to be the only opponent of any celebrity. By the liberal contributions of his friends in England, he was enabled to commence the printing of two extensive works, upon which he was zealously bent, a *Church History*, and an *Exposition of the Scriptures;* and during the progress of his final decline, he unremittingly urged their completion.

Since an illness which seized him at Philadelphia, in the year 1801, he never recovered his former state of health. His complaint was constant indigestion, and a difficulty of swallowing food of any kind. But during this period of general debility, he was busily employed in printing his *Church History*, in writing the first volume of his *Notes on the Scriptures*, and in making new and original experiments. During this period, likewise, he composed his pamphlet of *Jesus and Socrates Compared*, and reprinted his *Essay on Phlogiston.*

From about the beginning of November 1803, till the middle of January 1804, his complaint grew more serious; yet, by judicious medical treatment and strict attention to diet, he, after a time, seemed to be, if not regaining strength, at least not getting worse; and his friends fondly hoped that his health would continue to improve as the season advanced. He, however, considered his life as very precarious. Even at this time, besides his miscellaneous reading, which was at all times very extensive, he read through all the works which are quoted in his *Comparison of the different Systems of Grecian Philosophers with Christianity;* composed that work; and transcribed the whole of it in less than three months, thus leaving it ready for the press.

In the last fortnight of January, his fits of indigestion became more alarming than ever, his legs swelled, and his weakness increased. Within two days of his death he became so weak, that he could walk but a little way, and that with

Primæ viæ ‖ Primer seisin.

great difficulty. He was fully sensible that he had not long to live, yet he talked with cheerfulness to all who called for him. He dwelt upon the peculiarly happy situation in which it had pleased the Divine Being to place him in life; the great advantage he had enjoyed in the acquaintance and friendship of some of the best and wisest men of the age in which he lived; and the satisfaction he derived from having led an useful as well as a happy life. On the 9th of February 1804, he breathed his last, so easily, that those who were sitting close to him did not immediately perceive his exit. He had put his hand to his face, which prevented them from observing the last moment of his being.

In the constitution of Dr. Priestley's mind, great ardour and vivacity of intellect were united with a mild and placid temper. With a zeal for the propagation of truth which nothing could subdue, he joined a calm patience, and an unruffled serenity of temper, which rendered him proof against disappointments. The rights of private judgment were rendered sacred to him by every principle of his understanding, and his heart would not have suffered him to injure his bitterest enemy. He was naturally disposed to be cheerful, and when his mind was not occupied with serious thoughts, he could unbend, with playful ease and negligence, in the private circle of friends; but in large and mixed companies, he commonly spoke little. In the domestic relations of life he was uniformly kind and affectionate; his parental feelings were those of the tenderest and best of fathers; and not even malice itself could ever fix a stain upon his private conduct, or impeach his integrity.

PRIMÆ VIÆ, amongst physicians, denote the whole alimentary ducts; including the œsophagus, stomach, and intestines, with their appendages.

PRIMARY, first in dignity, chief, or principal.

PRIMARY QUALITIES OF BODIES. See METAPHYSICS.

PRIMATE, in church polity, an archbishop, who is invested with a jurisdiction over other bishops.

PRIME, PRIMUS, an appellation given to whatever is first in order, degree, or dignity, amongst several things of the same or a similar kind. Thus we say, the prime minister, prime cost, and so of others.

Prime is sometimes used to denote the same with decimal, or the tenth part of an unit.

PRIME FIGURE, in *Geometry*, one which cannot be divided into any other figures more simple than itself; as a triangle amongst planes, and the pyramid amongst solids.

PRIME OF THE MOON, is the new moon when she first appears, which is about three days after the change.

PRIME VERTICAL, is that vertical circle which passes through the poles of the meridian, on the east and west points of the horizon; and hence dials projected on the plane of this circle are called *prime vertical*, or *north and south dials*.

PRIME, in the Catholic Church, is the first of the canonical hours succeeding to lauds.

PRIMER SEISIN, in *feudal law*, was a feudal burden, only incident to the king's tenants *in capite*, and not to those who held of inferior or mesne lords. It was a right which the king had, when any of his tenants *in capite* died seized of a knight's fee, to receive of the heir, provided he were of full age, one whole year's profits of the lands if they were in immediate possession, and half a year's profits if the lands were in reversion expectant upon an estate for life. This seems to be little more than an additional relief; but grounded upon this feodal reason, that by the ancient law of feuds, immediately upon the death of a vassal the superior was entitled to enter and take seisin or possession of the land, by way of protection against intruders, till the heir appeared to claim it, and receive investiture; and for the time the lord so held it, he was entitled to take the profits; and unless the heir claimed within a year and day, it was by the strict law a forfeiture. This practice, however, seems not to have long obtained in England, if it ever did, with regard to tenures under inferior lords; but, as to the king's tenures *in capite*, this *prima seisina* was expressly declared, under Henry III. and Edward II., to belong to the king by prerogative, in contradistinction to other lords; and the king was entitled to enter and receive the whole profits of the land till livery was sued; which suit being commonly within a year and day next after the death of the tenant, therefore the king used to take at an average the *first-fruits*, that is to say, one year's profits of the land. And this afterwards gave a handle to the pontiffs, who pretended to be feudal lords of the church, to claim, in like manner, from every clergyman in England, the first year's profits of his benefice, by way of *primitiæ* or first-fruits. But all the charges arising by primer seisin were taken away by the 12 Car. II., c. 24.

Priming ‖ Primogeniture.

PRIMING, in *Gunnery*, the train of powder that is laid from the opening of the vent along the gutter or channel on the upper part of the breech of the gun, which, when fired, conveys the flame to the vent, by which it is further communicated to the charge, in order to discharge the piece. This operation is only used on shipboard at the proof, and sometimes in garrison; for, upon all other occasions, tubes are used for the purpose.

PRIMING, amongst painters, signifies the laying on of the first or original colour.

PRIMIPILUS, in *Antiquity*, the centurion of the first cohort of a legion, who had the charge of the Roman eagle.

PRIMITIÆ, the first-fruits gathered off the earth, and of which the ancients made presents to the gods.

PRIMITIVE, in *Grammar*, is a root or original word in a language, in contradistinction to *derivative*. Thus, *God* is a primitive; *godly*, a derivative; and *god-like*, a compound.

PRIMOGENITURE, or the right of the first-born, has amongst most nations been very considerable. The first-born son, in the patriarchal ages, had a superiority over his brethren, and, in the absence of his father, was the priest of the family. Amongst the Jews, he was consecrated to the Lord, had a double portion of the inheritance, and succeeded in the government of the family or kingdom. It is, however, remarkable, and unquestionably shows the connection between this institution and the birth and office of our Saviour, that if a woman's first child were a girl, neither she nor the children that came after her were consecrated.

In almost every nation of Europe, the right of primogeniture prevails at present in some degree, but it did not prevail always. The law which calls the elder-born to the crown, preferably to the others, was not introduced into France till a late period; it was unknown to the first race of kings, and even to the second. The four sons of Clovis shared the kingdom equally amongst themselves, and Louis le Debonnaire did the same; it was not till the race of Hugh Capet succeeded, that the prerogative of succession to the crown was appropriated to the first-born.

Mr. M'Culloch, in one of the Notes to his valuable edition of Smith's *Wealth of Nations*, makes the following observations on this subject. "Though there can be little doubt of the injurious consequences that must always flow from every attempt to regulate the succession to property by means of compulsory regulations, there are good grounds for thinking that the *custom* of primogeniture, or the custom of leaving the whole, or the greater part of the paternal estate, to the eldest son, to the exclusion of his brothers and sisters, has been advantageous. The prejudices of most political philosophers against primogeniture seem to rest on no solid foundation. Dr. Smith says, that it is a custom which, 'in order to enrich one, beggars all the rest of the children;' but, so far from agreeing in this opinion, we cannot help thinking, that to it may be fairly ascribed much of the industry, freedom, and civilization of modern Europe; and

Primum, Prince.

that were it abolished, and the custom of equally dividing landed property established in its stead, all the children of landlords, the youngest as well as the oldest, would be reduced to a state of comparative poverty, at the same time that the prosperity of the other classes would be greatly impaired."

"This custom of *gavelling*, or dividing the paternal inheritance, was not confined to any particular sort of property, but extended to leasehold as well as freehold. And so strongly was it rooted in the public esteem, that it was to no purpose that a landlord inserted a clause in the lease of a farm prohibiting its subdivision. The courts of law were hostile to such limitations; and the juries, before which a case of this description was occasionally tried, if they returned a verdict in favour of the landlord, almost uniformly awarded only nominal damages. The consequences resulting from the combined operation of this custom and law, have been exactly such as might have been anticipated. Instead of increasing with the increase of capital, and the more general diffusion of a knowledge of the correct principles of agriculture, the farms in the possession of the Irish tenantry have been gradually reduced in most instances to mere patches."

"In Scotland a totally different system has been followed, and with the happiest results. The succession to farms, as well as estates, has been long regulated in that part of the empire by the law of primogeniture. The tenant of a Scotch farm has no power, unless a provision to that effect be inserted in his lease, which is very rarely done, to devise his interest in it. He can neither sublet nor subdivide his farm; and, at his death, it descends entire to his heir-at-law. The younger children are not taught from infancy to trust to the land for support; on the contrary, they are early made aware that farming is not a profession on which they can enter, and that it is indispensable they should apply themselves to something else. In consequence, they either establish themselves in towns or emigrate to other countries; and perhaps there is no one circumstance that has contributed so much as this to inspire Scotchmen with the adventurous enterprising spirit for which they are celebrated. The agricultural population is, in this way, kept down to its proper level; and prudential habits are very generally diffused. Instead of becoming less, farms in Scotland are gradually becoming larger, according to the increase in the capital of those engaged in the business of agriculture. No one prosecutes farming as a means of acquiring a miserable subsistence, but as a means of employing capital with advantage. There is, however, great reason to fear that the enfranchising of the tenants will have a most injurious influence over agriculture."[1]

By the ancient custom of *Gavel-kind*, still preserved in Kent, and in some other parts of our island, primogeniture is of no account. "The lands," says Blackstone, "descend, not to the eldest, youngest, or any one son only, but to all the sons together."[2]

PRIMUM MOBILE, in the Ptolemaic astronomy, the ninth or highest sphere of the heavens, the centre of which is that of the world, and in comparison with which the earth is but a point. This is supposed to contain within it all other spheres, and to give them motion, turning them quite round, as well as revolving itself, in twenty-four hours.

PRINCE, PRINCEPS, in polity, a person invested with the supreme command of a state, and independent of any superior.

PRINCE likewise denotes a person who is a sovereign in his own territories, yet holds of some other as his superior. Such are the princes of Germany, who, though absolute in their respective principalities, are bound to the emperor in certain services.

PRINCE also denotes the issue of princes, or those of the royal family. In France, before the Revolution, they were called "princes of the blood," and during the short continuance of the constitution of 1791, "French princes." In England the king's children are called "sons and daughters of England;" the eldest son is created Prince of Wales; the cadets are created dukes or earls, as the king pleases; and the title of all the children is "royal highness."

Prince ‖ Prince of Wales's Island.

PRINCE OF THE SENATE, in ancient Rome, the person who was the first called in the roll of senators, whenever it was renewed by the censors. He was always of consular and censorian dignity.

PRINCE'S METAL, or PINCHBECK, an alloy of copper and zinc, which has a resemblance to gold.

PRINCE OF WALES'S ISLAND, called also PULO PENANG, and BETEL-NUT ISLAND, is situated on the western coast of the Malay peninsula, from which it is separated by a narrow strait, not more than two miles in breadth. It forms an excellent harbour, which is capacious, and well defended from all winds, and it affords anchorage for the largest ships. The principal entrance is from the north-west; but there is also a fine channel to the southward. There is an inner harbour, in which ships may receive every kind of repair that can be performed without going into dock. The area of the island is estimated at 160 square miles. It is nearly five leagues in length and seven or eight miles in breadth. It is of an irregular four-sided figure, which is highest on the north side and shortest on the south; and is intersected by a range of lofty hills, which decrease in magnitude as they approach the south, and in which are the sources of numerous streams, that supply the island with abundance of water. These hills are of a moderate height. The highest, namely, the Flag-staff Hill, does not rise to more than 2500 feet above the level of the sea. Here the heat is comparatively moderate; the thermometer seldom rises above 74°, and often falls to 66° whilst in the plains it ranges from 76° to 90°. The climate is moist, and the rains are heavy. Except in the dry hot months of January and February, scarcely a day passes without rain, which is heaviest in November and December.

The island generally possesses a fertile soil, being for the most part a light black mould, mixed with gravel, clay, and in many parts sandy. It is chiefly formed from the decayed leaves of trees, from which originated a fine vegetable mould, the whole island having been for ages covered with immense forests. This has in some degree disappeared as the woods were cleared and the surface exposed to the weather; but the soil in the interior is still adapted for any sort of tropical produce. Cultivation is extended over the northern, and nearly the whole of the southern and eastern sides of the island. The principal productions are pepper, betel-nut, betel-leaf, cocoa-nuts, coffee, sugar, parsley, ginger, yams, sweet potatoes, and a great variety of vegetables. The island abounds in many species of fruits, such as the mangosteen, rambosteen, pine-apples, guavas, oranges, citrons, pomegranates, and others. The island also produces cloves, nutmegs, cinnamon, pimento, kyapootee, cotatova, and numerous other plants from the Moluccas and Eastern Isles. Pepper is one of the chief articles of cultivation. This island also affords the elastic gum vine, or American caoutchouc. It grows to the thickness of an arm, creeping along the ground to the distance of two hundred paces, and then ascending amongst the branches of high trees. The forests which are found in this island abound in excellent timber for ship-building, and supply masts of any dimensions, lower masts of any size having been procured here for a seventy-four gun-ship.

This island was originally granted, in 1785, by the King

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[1] Smith's *Wealth of Nations*, with Notes by M'Culloch, p. 564. 1838, in one vol. 8vo.

[2] *Comment.* book ii. chap. 6.

Prince of Wales's Island.

of Queda, to Captain Francis Light, of a country ship, who had married his daughter. It was then transferred to the East India Company, and accepted; being peculiarly adapted as a mercantile station for vessels arriving from all the Malay ports, the Moluccas, Borneo, the Celebes, and the Philippine Islands. A small detachment was accordingly sent from Calcutta, under the command of Captain Light, who in 1786, took possession of the island, for the use of the East India Company. But those early settlers had great difficulty in clearing the country, encumbered with an immense forest, with swamps which required to be drained, and ravines which it was necessary to fill up. A town called George Town was, however, marked out, and within a year sixty Chinese families had settled in it, besides great numbers of Malays, Buggepes, and other Eastern traders. The port was made free to all nations, and in a very short time numerous adventurers flocked to the settlement, commerce and population rapidly increased, and cultivation was extended. In 1797 the population amounted to 6,937, exclusive of Europeans and the garrison; and in 1805, it had risen to 10,310. They have since been progressively increasing, and exhibit an uncommon diversity of races, consisting of British, Dutch, Portuguese, Americans, Arabs, Parsees, Chinese, Chulias, Malays, Buggepes, Birmans, Siamese, Javanese, &c. In 1805, the settlement having grown in wealth and importance, it was determined to erect it into a regular government, subordinate only to the Governor-General of India. But, on account of the enormous expense of this establishment, some modifications were made in these arrangements in the year 1808. This island is resorted to by invalids from the continent in search of health; but if we may judge from the number of governors who have died here, the change is scarcely for the better. Captain Light died in 1794; and he was succeeded by Mr. Manningham, who died soon after in Bengal. In 1796 Major Macdonald took the charge, and died at Madras in 1799. Sir George Leith, who succeeded him, lived and returned to Europe; but the Hon. C. Bruce, who arrived as governor in the year 1810, only survived till next December.

The fort, which is called Fort Cornwallis, is incapable of defence, from its size and construction. It is built upon the north-eastern point of the island, and large sums have been spent without completing it. It contains barracks for the military, an arsenal, a magazine, and several military storehouses. Of late years the sea has made great encroachments on the northern face of the fort, and along the esplanade. The town is of considerable extent, and the streets, which cross each other at right angles, are spacious and airy. There is a large pier for landing and shipping goods; a government house, a church, a jail, and several substantial bridges have been built; whilst the fortifications have been improved and strengthened, and the public roads repaired and widened. The markets are well supplied with fish of various descriptions and of excellent quality; with poultry of all sorts, pork, grain of every description, and a profusion of vegetables and fruit. The beef and veal are not of a good quality. Sheep are imported from the continent of India; whilst Sumatra and the Malay peninsula furnish a supply of goats. Milk and butter are dear and scarce. A great trade is carried on with Europe, India, and the islands in the Eastern seas. Ships that are trading to the east, especially to China, touch here, where they procure such refreshments or articles of trade as they require. Vessels from Europe, bound for China, also touch here, and load large quantities of tin, canes, rattans, sago, pepper, betel-nut, luche-de-mar, edible birds' nests, &c., for the China market. This small island is the emporium of the whole trade of the Straits of Malacca and adjacent islands. The imports from Europe, either directly or from the other presidencies, are generally European manufactures in iron and steel, such as anchors, cutlery of all sorts, fire-arms, nails; also tin-ware, patent shot, sheet-lead, sheet-copper, iron in bars, books, pamphlets, boots and shoes, cables, canvas, cabinet ware, cloths, and cassimeres, glass ware, hats, haberdashery, hosiery, musical and mathematical instruments, oilmen's stones, painters' colours, plated wire, watches, malt liquor, and European wines of all sorts. From Bengal, the imports are opium, grain, iron, steel, marine stores, and piece goods; from the Coromandel coast, salt, tobacco, cloths, evir rope and yarns, handkerchiefs, chintzes, &c.; from Bombay and the Malabar coast, cotton, salt, a few piece goods, red wood, sandal wood, sharks' fins, myrrh, piece goods, &c.; from Sumatra, pepper, benzoin, camphire, and gold dust; from Acheen and Pedeer, gold dust, betel-nut, pepper, rice, and Acheen cloths. Tin is imported from the east coast and from Junkceylon; also pepper, sugar, oil, rice, tobacco, elephants' teeth, edible birds' nests, &c.; spices from the Moluccas; gold dust, sago, and black wood from Borneo; and from China, tea, sugar, lustrings, velvet, paper, umbrellas, china-ware, quicksilver, and generally every article required by the Chinese settlers, though British produce has in many cases superseded that of China. Other articles from China are, raw silk, copper ware, China camphor, China root alum. The exports consist of many of those articles which are sent to Sumatra, Junkceylon, Java, Borneo, China, Bengal, Coromandel, as they are required.

Prince's Isle ‖ Principal.

PRINCE'S ISLE, situated off the north-westernmost extremity of the Island of Java. The land is generally low and woody, and the highest eminence on it is called the Pike. It contains a town called Samadang, divided into two parts by a river. Such ships as touch here may be supplied with fish, deer, plantains, pine-apples, rice of the mountain kind, yams, and other vegetables. Long. 10512. E. Lat. 6. 30. S.

PRINCE WILLIAM'S ISLANDS, a cluster of islands in the Pacific Ocean, discovered by Tasman in 1643. Long. 179. E. Lat. 17. 19. S.

PRINCE WILLIAM HENRY'S ISLAND, in the Pacific Ocean, discovered in the year 1790 by Lieutenant Ball. It is about seventy miles in circumference, elevated, of a luxuriant and picturesque appearance, and well peopled. Long. 149. 30. E. Lat. 1. 32. S.

PRINCESS ROYAL'S HARBOUR, on the south-western coast of New Holland, and the western part of King George the Third's Sound. The passage into it is a quarter of a mile in width. Long. 118. 9. E. Lat. 35. 3. S.

PRINCIPAL, the chief and most necessary part of a thing. The principal of a college or hall is the master thereof.

In commerce, principal is the capital of a sum due or lent, and is so called in opposition to interest. It also denotes the first fund put by partners into a common stock, by which it is distinguished from the calls or accessions afterwards required.

PRINCIPAL, in *Music*, see ORGAN. The term principal is also used in music to designate the more distinguished part written for an instrument where there are several parts written in harmony, and where one of these parts is intended to be the chief and most conspicuous; as in a violin concerto, *Violino Principale*, and so of other instruments.

PRINCIPAL POINT, in *Perspective*, is a point in the perspective plane, upon which falls a line drawn from the eye perpendicular to the plane. This point, which is in the intersection of the horizontal and vertical plane, is also called the *point of sight*, and *point of the eye*.

PRINCIPAL RAY, in *Perspective*, is that which passes perpendicularly from the spectator's eye to the perspective plane, or picture. The point where this ray falls upon the plane, is thence denominated by some the *principal point*, but other writers call it *the centre of the picture*, and *the point of concurrence*.

Principle || Pringle.

PRINCIPLE, in science, is a truth, admitted without proof, from which other truths are inferred by a chain of reasoning. Principles are of two kinds, *primary* and *general;* and to the latter the name of *axioms* is sometimes given, on account of their importance and dignity. An axiom, or general principle, when the terms in which it is expressed are understood, must be a self-evident truth; but from its very nature it cannot be a first truth. Our first truths are all *particular*. A child knows that two particular lines, each an inch long, are equal to one another, before he has formed any general notions of length and equality. "Things equal to one and the same thing are equal to one another," is the first of Euclid's axioms; and an axiom it undoubtedly is, but to no man has it been a first truth. It is, if we may use the expression, a genus or class of truths, comprehending under it numberless individuals. Were a full-grown man introduced into the world without a single idea in his mind, as we may suppose Adam to have been, he would instantly perceive, upon laying together three pieces of wood, each a foot long, that they were all equal in length; and if he were to cut another to the same length with any one of them, he would find, upon trial, that it was of the same length with them all. After a few simple experiments of this kind, he would, by a law of human thought, infer, that all things equal in length, or in any other dimension, to any one thing, are in that dimension equal to one another.

It was not, therefore, with such weakness as some have imagined, that Hobbes declared those propositions commonly called axioms, not to be primary but secondary principles. A primary principle deserves not the name of an axiom, as it is only a particular truth including in it no other truth. There is not one of Euclid's axioms which has not been the result of induction, though we remember not the time at which the induction was made. That the whole is greater than any of its parts is a general truth which no man can controvert; but every one discovered that truth by observing, that his body was larger than his head, his foot, or his hand, that a mountain is larger than a mole-hill in the middle of it, and that a piece of timber, measuring what is called a yard, is longer than any one of the divisions marked upon it, which are termed inches. Particular objects are observed by the senses, and treasured up in the memory; and the intellect, by its constitution, compares them together, marks in what they agree and disagree, and thence draws its axioms or general principles. He, therefore, who should admit the truth of an axiom, and deny the evidence of sense and perception, would act as absurdly as he who accepts payment in a bank-bill, and refuses it in the individual pieces of gold or silver which that bill represents. General axioms are of infinite use in the pursuits of science; but it is not because they create new truths; they only shorten the process in the discovery of such as might be found, with labour, through the medium of particular propositions.

PRINGLE, Sir John, an eminent physician and philosopher, was a younger son of Sir John Pringle of Stitchel, in the shire of Roxburgh, baronet. He took the degree of doctor of physic at Leyden, in 1730, and published there his *Dissertatio Inauguralis*. After having been some years professor of moral philosophy at Edinburgh, he was, in June 1745, appointed physician to the Duke of Cumberland, and physician-general to the hospital of the forces in Flanders, where the Earl of Stair appears to have been his patron. In February 1746, Dr. Pringle, Dr. Armstrong, and Dr. Barker, were nominated physicians to the hospital of lame, maimed, and sick soldiers, behind Buckingham House; and in April 1749, he was appointed physician in ordinary to the king. The following year he published *Observations on the Nature and Cure of Hospital and Gaol Fevers, in a Letter to Dr. Mead*, 8vo.; and in 1752 he favoured the public with the result of his long experience, in an admirable treatise, under the title of *Observations on the Disorders of the Army in Camp and Garrison*, 8vo. On the 14th of April 1752, he married Charlotte, second daughter of Dr. Oliver, an eminent physician at Bath. In 1756 he was appointed, jointly with Doctor afterwards Sir Clifton Wintringham, physician to the hospital for the service of the forces of Great Britain. On the accession of George III., Dr. Pringle was appointed physician to the queen's household in 1761, and physician in ordinary to the queen in 1763, in which year he was admitted of the college of physicians in London; and on the 5th of June 1766, he was advanced to the dignity of baronet of Great Britain. In 1772 he was elected president of the Royal Society, where his speeches for five successive years, on delivering the prize-medal of Sir Godfrey Copley, gave the greatest satisfaction. Sir John Pringle was, in 1777, appointed physician-extraordinary to the king. He was also a fellow of the College of Physicians at Edinburgh, and of the Royal Medical Society at Paris, member of the Royal Academies of Paris, Stockholm, Göttingen, and of the Philosophical Societies at Edinburgh and Haerlem; and he continued president of the Royal Society till November 1778, after which period he gradually withdrew from the world, and in 1781 quitted his elegant house in Pall Mall, where he had long distinguished himself as the warm friend and patron of literary men of every nation and profession. Having made an excursion to his native country, he returned to London in the latter end of the year, and died on the 18th of January 1782, greatly beloved and respected. Having no children, he was succeeded in his estate, and also, agreeably to the limitation of the patent, in title, by his nephew, Sir James Pringle. Amongst his communications to the Royal Society, the following are the principal, viz. 1, Some Experiments on Substances resisting Putrefaction, *Phil. Trans.*, No. 495, p. 580, and No. 496, p. 525, 550, reprinted with additions in Martin's Abridgment, vol. xi. p. 1365; 2, Account of some Persons seized with the Gaol Fever by working in Newgate, and of the manner by which the Infection was communicated to one entire Family, vol. xlviii., p. 42; 3, A remarkable Case of Fragility, Flexibility, and Dissolution of the Bones, ib. p. 297; 4, Account of the Earthquake felt at Brussels, vol. xlix, p. 546; 5, Account of the sinking of a river near Pontypool in Monmouthshire, ibid., p. 547; 6, Account of an Earthquake, felt February 18, 1756, along the coast of England, between Margate and Dover, ibid., p. 579; 7, Account of the Earthquake felt at Glasgow and Dunbarton, also of a shower of dust falling on a Ship between Shetland and Iceland, ibid., p. 509; 8, Several Accounts of the Fiery Meteor which appeared on Sunday, November 26, 1758, between eight and nine at night, vol. l., p. 218; 9, Account of the Virtues of Soap in dissolving the Stone, in the Case of the Reverend Mr. Matthew Simson, ibid., p. 221; 10, Account of the effects of Electricity in Paralytic Cases, ibid., 481; 11, Some Account of the Success of the *Vitrum Ceratum Antimonii*, printed in the *Edinburgh Medical Essays*, vol. v.

Prinkipo.

PRINKIPO, the largest and most easterly of the Prince's islands. They are situated in the bay of Marmora, about a league distant from the coast of Asia Minor. It is about a mile in length and half a mile in breadth, and contains what was formerly a considerable and well-built town, but which is now in a ruinous condition. The island was formerly inhabited by the French merchants, who have however abandoned it, owing to the brackishness of the water. It is now inhabited by Greeks, who support themselves by selling wine and provisions to the pleasure parties which arrive from Constantinople. Long. 28. 56. E. Lat. 40. 51. N.

PRINTING.

Printing. PRINTING is the art of taking one or more impressions from the same surface, whereby characters and signs, cast, engraven, drawn, or otherwise represented thereon, are caused to present their reverse images upon paper, vellum, parchment, linen, and other substances, in pigments of various hues, or by means of chemical combinations, of which the components are contained on or within the surface from which the impression is taken, or in the fabric of the thing impressed, or in both.

The most important branch of printing is what is called *letter-press* printing, or the method of taking impressions from letters and other characters *cast* in relief upon separate pieces of metal, and therefore capable of indefinite combination. The impressions are taken either by superficial or surface pressure, as in the common printing press, or by lineal or cylindrical pressure, as in the printing machine and roller-press. The pigments or inks, of whatever colour, are always upon the surface of the types; and the substances which may be impressed are various. Wood-cuts and other engravings *in relief* are also printed in this manner.

Copperplate printing is the reverse of the above, the characters being *engraven* in intaglio, and the pigments or inks contained within the lines of the engravings, and not upon the surface of the plate. The impressions are always taken by lineal or cylindrical pressure; the substances to be impressed, however, are more limited. All engravings in intaglio, on whatever material, are printed by this method.

Lithographic printing is from the surface of certain porous stones, upon which characters are *drawn* with peculiar pencils. The surface of the stone being wetted, the chemical colouring compound adheres to the drawing, and refuses the stone. The impression is taken by a scraper, that rubs violently upon the back of the substances impressed, which are fewer still in number. Drawings upon zinc and other materials are printed by this process. (See LITHOGRAPHY.)

Cotton and calico printing is from surfaces engraven either in relief or in intaglio. The chemical compounds are either on or within the characters, as pigments or chemical colours, or in the fabric to be printed, but mostly in both; the combination of chemical substances producing colour when the fabric and the engraving are brought into contact. The impression is either superficial or lineal, but mostly lineal. (See DYEING.)

LETTER-PRESS PRINTING.

History. The origin and history of an art which has exercised such an influence on civilization, and contributed in so essential a manner to the cultivation of the human intellect, have naturally become a matter of inquiry amongst the learned, and have almost as naturally been the source of earnest controversy; for there are few effects of human invention or industry that have been originated and brought to perfection at a particular epoch, without any previous train of thought or circumstance, so that the precise day or year could be noted in which the perfect Minerva started forth in full maturity. On the contrary, it is difficult to say at what period of time the germ of the art of printing did not exist. So obvious is the reproduction of similar appearances from an impression of the same surface, that the most early of mankind must have noted it; and even the impression of a foot or a hand must have suggested a simple and intelligible mode of conveying an idea, before the invention of any kind of writing. Accordingly, these and similar signs are found to compose the chief characters of the earliest writing, which is the symbolic. History.

Observing this general law of the gradual perfectibility of human arts, we must look back to the most remote ages for the first steps of that of printing. We shall accordingly find certain evidence, that, more than two thousand years before our era, a method of multiplying impressions, rude and imperfect in the extreme, was certainly practised; but although the general fact is universally allowed, it is extremely difficult to give satisfactory examples. Turning, however, to Egypt, we shall find such traces as sufficiently prove the truth of the general statement.

The ingenuity of mankind had for a long period confined itself principally to the more easy and beautiful art of colouring surfaces with pigments, in the imitation of surrounding objects; and had their desires been limited to the production of a single essay, they would have made no deviation from an art so beautiful, and so susceptible of taste and variety. But when the wants and conveniences of an advanced state of society required effects of a more lasting character, less costly, and of more general application, a method of producing the same, or nearly the same effect, with considerable rapidity, very soon presented itself; and the sacred inscriptions at first painted or engraved upon the figures of the deities, and possibly upon articles of domestic use, were impressed upon plastic models with equal ease and certainty.

Babylonian bricks.

Babylon presents us with some remarkable specimens of the progress of this art, which may be received as the earliest instances of *imprinting*, the epoch of which can be in any degree approximated. These are found on the bricks many of which have been discovered on the site of the departed city. That the Assyrians should have thought it worth while to print inscriptions upon materials destined to be built into their dwellings (and every *kiln-burned* brick amongst these vast ruins is stamped with an inscription), argues that the process was not only not an uncommon one, but also that there probably existed at the same time a more advanced and more elegant usage of imprinting in their domestic and ornamental arts. Specimens of these bricks may be seen in the library of Trinity College, Cambridge, in the British Museum, in the library of the East India Company, and in several private collections. Those at Cambridge are parallelopipeds of thirteen inches in length by three in thickness, and are made of clay mixed with reeds, and burned in the kiln. On one of the large surfaces is an indentation, produced by the forcible impression of a stamp, from the face of which a large portion has been cut away, leaving a series of figures in relief. The depression produced by this stamp is six inches and one eighth by three and five eighths in extent, and about three eighths of an inch in depth. It is exceedingly rude in execution, bearing a strong resemblance to the impressions of the names of the makers to be found upon the backs of inferior earthen-ware; and is produced by exactly the same means, the process of baking entirely destroying whatever sharpness the soft mass may have had. The inscription is clearly stamped in after the clay has been turned out of the mould, and is not produced by any part of it; for in all known specimens it is placed in different positions, and never stands parallel to the edges of the brick, being in fact put on more or less awry, according to the care and manual skill of the workman. The surface of the brick around the depression is forced up considerably, which is exactly the effect of pressing the hand or any substance into a plastic material; and the edges both of the parent depression and of the

History. figures present the effect of the stamp having been drawn up whilst the clay was still damp and adherent to it. The inscription consists of six vertical columns, containing thirty-eight figures; the columns are divided by bold straight lines. The characters are those usually called the Persepolitan or arrow-headed, but better described by the French as nail-headed. They are found very widely spread over Asia, but most plentifully at Persepolis. No one has hitherto made any considerable progress in deciphering them, nor have the learned been able to determine whether they are alphabetic, syllabic, hieroglyphic, or signs representing one or more words, as in the Chinese.

Curious as are these specimens of Assyrian art, Babylon presents us with others still more choice. These are a kind of cylinder, shaped like a barrel, but rather longer in proportion to the width. The one described is seven inches in height, and three inches in diameter at the ends; it is made of fine clay, and baked. The inscriptions are in the same character as those found upon the bricks, arranged in vertical lines, commencing, or ending, according to the way of reading, near the middle of the cylinder, where it is of the greatest diameter, and running down to the foot. There are consequently two inscriptions, one on either half; and there is an interval running *round* the cylinder between the two, without any impression. Counting upon a drawing, there are thirty-two vertical lines in either inscription, and consequently they are less than a quarter of an inch in width. There are thirty figures in one of the columns; and each figure would therefore occupy a space of less than one eighth of an inch. The figures are perfectly sharp and distinct, and the whole cylinder is a beautiful specimen of art. The one to which we allude is in the library of Trinity College, Cambridge; but many very excellent specimens have lately been deposited in the British Museum, an actual inspection of which, and of other cognate relics, will enable the curious to form a much better idea of their excellence than any description, however diffuse. They are of all sizes, from a foot in height to the size of a signet, to which purpose probably they were sometimes applied, since some specimens are perforated as if intended for the insertion of a wire or cord; indeed there are specimens of somewhat similar cylinders with the wire inserted for thumb-rings. Perhaps those a little larger were hung round the neck as charms and amulets.

That a similar art was known to the inhabitants of the old world generally, may safely be assumed. It is therefore not a little remarkable that people so original and ingenious as the Greeks, and so imitative as the Romans, should have left almost no vestige of their having practised any such mean as this to multiply their beautiful creations of fancy, or to embellish the tasteful appliances of domestic life; especially when we consider the easy adaptation of the art to pottery, and the beauty, taste, and ingenuity which they exhibited in that manufacture. For, excepting a few paltry designs *en creux* on some of the coarser specimens, and a few marks upon the Roman military vessels, evidently stamped, there is no appearance of either people having had any idea of this kind; the sister art of taking impressions in seals not being fairly to be classed under this head. There are, however, in the British Museum some instruments presenting a singular instance of how very nearly one may approach to an important discovery, and yet pass on unheeding. These stamps are of brass, and amongst others the signet of C. Cæcilius Hermia. The face of this is two inches by four fifths of an inch, and the inscription, History.

CICAECILI
HERMIAE. SN.

with a border, is in relief, the surrounding parts being cut away to a considerable depth. It should be especially noticed, that the surface of the field is very rough; and there is a ring at the back by which it could be handled or suspended.[1] These circumstances render the use of it very clear. It would be very much easier to incise the required inscription, and to let the field stand (indeed the art of engraving *en creux* was well known and used), than to cut away the field and leave the letters in relief; and it would produce a much more beautiful effect if it were used to impress any soft substance; whereas, cut as it is, the impression sunk into the wax or clay would not only be ugly, but illegible, and the rough surface of the field would present the most ungainly appearance upon the prominent parts of the wax, being the parts most presented to the eye. Its use therefore is evident. The relieved inscription, and no other part, being covered with ink or pigment, was impressed upon an even surface (papyrus, linen, parchment), and consequently left a perfect but reversed imprint of itself. This is the precise effect of printing with types. Now, from the circumstance of Cæcilius being a person of no known eminence, it is a fair conclusion that such an instrument was not uncommon amongst those who either were not able to write, or were engaged in public employments requiring a great number of signatures, or who were accustomed to commit the signing of documents to subordinates on their behalf. From the Greek agnomen, Cæcilius probably lived under the emperors, when literature had become one of the pursuits of the great, and when the difficulties and expense of procuring books by the slow process of copying were bitterly felt. It is singular, therefore, that they should have overlooked so obvious an improvement upon their own signets as the engraving whole sentences and compositions upon blocks, and thence transferring them to paper, even if they had gone no farther than this.[2]

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[1] The Antiquarian Society of Newcastle possesses a similar stamp with a Greek inscription.

[2] The Chinese printing is not unlike this, and must by no means be supposed to have much similarity to the modern art. They assert that it was used by them several centuries before it was known in Europe; in fact, fifty years before the Christian era. They certainly may have used their method centuries before our art, for it differs in nothing but extent from that of the old Roman. The following is a description of their method at the present day, and it is probably the same in every respect as that in practice two thousand years ago in an empire where nothing is changed. As their written language consists of from eighty to one hundred thousand characters, it would be utterly impracticable to use moveable types, and the use of block-printing would be the most easy and rapid. The sentences, therefore, desired to be multiplied, being drawn upon their thin paper, this is made to adhere with the face downward to a block of soft wood, so that the characters appear through *reversed*. The plain wood is then cut away with most wonderful rapidity, and the drawing left in relief. Both sides of the block are similarly operated upon. The engraved wood is then properly arranged upon a frame, and the artist, with a large brush, covers the whole surface, the field as well as the relief, with a very thin ink; he then lays very lightly over it a sheet of paper, and passes a large soft brush over it, so slightly, yet so surely, that the paper is pressed upon the raised figures, and upon no other part. The rapidity with which this is performed is extraordinary; for Du Halde asserts that one man can print ten thousand sheets in one day, a number which would appear incredible, did not very good testimony exist at the present time that one man can print seven hundred sheets per hour. The method of putting the thin sheets together when printed, is as different from ours as their printing and mode of reading. The sheets are printed on one side only; but instead of the blanks being pasted together to form one leaf, the sheet is so folded that no single edge of paper is presented to the reader, but only the double-folded edge; the loose edges being all at the back of the book.

History. From this time a vast period elapses before any circumstance can safely be instanced as showing that the practice of transferring characters was known to any, even comparatively civilized people. From the rough and imperfect attempts above indicated, the first and most obvious advance was engraving pictures upon wooden blocks. The first practice of this is involved in obscurity, but most writers on the fine arts agree that the art was invented towards the end of the thirteenth century, by a brother and sister of the illustrious family of Cunio, lords of Imola, in Italy. By some the whole narrative is considered as apocryphal, but it is nevertheless generally admitted. The engravings were discovered by a Frenchman of the name of Papillon, in the possession of a Swiss gentleman, M. de Grœder, who deciphered for him the manuscript annotations found upon the leaves of the book in which they were bound. These purported that the book had been given to Jan. Jacq. Turine, a native of Berne, by the Count of Cunio, with whose family he, Turine, appears to have been intimately acquainted. Then follows a romantic history of the twins, and the cause of their invention. The book is entitled "The Heroic Actions, represented in figures, of the great and magnanimous Macedonian king, the bold and valiant Alexander; dedicated, presented, and humbly offered to the most Holy Father Pope Honorius IV., the glory and support of the church, and to our illustrious and generous father and mother, by us Alessandro Alberico Cunio, cavaliere, and Isabella Cunio, twin brother and sister; first reduced, imagined, and attempted to be executed in relief, with a small knife, on blocks of wood, made even and polished by this learned and dear sister; continued and finished by us together, at Ravenna, from the eight pictures of our invention painted six times larger than here represented; engraved, explained by verses, and thus marked upon the paper, to perpetuate the number of them, and to enable us to present them to our relations and friends, in testimony of gratitude, friendship, and affection. All this was done and finished by us when only sixteen years of age." This title is here given at full length, because, if genuine, it presents us at once with the origin, execution, and design of these first attempts at block-printing. The book consists of nine engravings including the title; the figures are tolerably well designed, and the draperies graceful, with here and there attempts at cross-hatching; under the principal personages are their names; above, are inscriptions indicating the subject, and below, four lines of poetical Latin explanatory of it; and in some part of each print is an inscription indicating the share the twins respectively had in the execution. The colour of the pigment is gray.

The first subject is Alexander on Bucephalus. Upon a stone, *Isabel. Cunio pinx. et scalp.*

The second subject, the Passage of the Granicus. *Alex. Alb. Cunio Equ. pinx. Isabel. Cunio scalp.*

The third subject, Alexander cutting the Gordian Knot. *Alex. Albe. Cunio Equ. pinx. et scalp.*

The fourth subject, Alexander in the tent of Darius. *Isabel. Cunio pinx. et scalp.*

The fifth, Alexander giving Campaspe to Apelles. *Alex. Alb. Cunio Eques pinx. et scalp.*

The sixth, the Battle of Arbela. *Alex. Alb. Equ. et Isabel. Cunio pictor. et scalp.*

The seventh, Porus brought to Alexander. *Isabel. Cunio pinx. et scalp.*

The eighth, the triumph of Alexander upon his entry into Babylon. *Alex. Alb. Equ. et Isabel. Cunio pictor et scalp.*[1]

From the dedication of this book to Pope Honorius IV., it is deduced that these engravings must have been executed between 1284 and 1285, inasmuch as this pope only enjoyed the pontificate two years; and it is suggested that a copy of it might be found in the library of the Vatican. The narrative appears to be confirmed by many incidental circumstances, which bear every evidence of not being the invention either of Papillon or his informer. The name of Alberico seems to have been a favourite with the family of Cunio, and a count of that name actually figures in history in the very year of the presumed invention; a relative of the twins, of course, not the male artist himself.

History. The interval between the time of the twin Cunio and the next mention of any similar usage is very perplexing; but upon examination it will appear that that long period was not altogether a blank in the art. The next earliest evidence is a document of the government of Venice, discovered amongst the archives of the Company of Printers in that city. It bears the date of 1441, and as it throws some degree of light upon the controversy relative to the invention of printing, it is here given from Ottley's History of Engraving.

"M CCCC XLI. October the 11th. Whereas the art and mystery of making cards and printed figures, which is used at Venice, has fallen into total decay; and this in consequence of the great quantity of playing-cards, and coloured figures printed, which are made out of Venice; to which evil it is necessary to apply some remedy; in order that the said artists, who are a great many in family, may find encouragement rather than foreigners. Let it be ordered and established, according to that which the said masters have supplicated, that from this time in future, no work of the said art that is printed or painted on cloth or on paper, that is to say, altar-pieces (or images), and playing-cards, and whatever other work of the said art is done with a brush or printed, shall be allowed to be brought or imported into this city, under pain of forfeiting the works so imported, and xxx livres and xii soldi, of which fine one third shall go to the state, one third to the Signori Giustizieri Vecchi, to whom the affair is committed, and one third to the accuser. With this condition, however, that the artists who make the said works in this city may not expose the said works to sale in any other place but their own shops, under the pain aforesaid, except on the day of Wednesday at St Paolo, and on Saturday at St Marco, under the pain aforesaid."

From this it seems manifest that the art of printing from wood-blocks was not lost, but, on the contrary, had been so long practised as to become an extensive and profitable business in Venice, and to spread over the Continent to such a degree as in turn to destroy the trade of the Venetian artists. The establishment of an important manufacture, and its decay, necessarily infer a long period. From the constant conjunction of the two arts of painting and printing in this document, we may infer (what the existence of prints and cards of later date prove) the method in which these figures and cards were manufactured, namely, that the outline was first printed, and that the colours and shading were filled in by the printer and illuminator. The history of playing-cards now becomes of some importance to the narrative. When cards first came into use is uncertain; but mention is made of them in the year 1254, when they were interdicted by St Louis on his return from the Crusade: they were also forbidden by the council of Cologne in 1281. In 1299 they are expressly mentioned under the name *carte;* and in "Das Gülden Spiegel," printed by Gunther Zainer in the year 1472, it is said that cards first came into Germany in 1300. An old French poet, who wrote "En l'an mil iij cent xxviij," has the line,

[1] It is not unlikely that the twins may have been directed in the choice of their subject by the identity of the name of the great conqueror with that of the brother; at least such coincidences are not without parallel in the history of literature.

History. "Jouent aux dex, aux cartes, aux tables." There is no evidence earlier than the Venetian decree to connect the art of printing from wood-blocks with the art of making cards; but as it is evident from that document that such connection did exist, it is a fair presumption that it originated not very long after the introduction of the game; and as the sum paid by Charles VI. for "trois jeux de cartes" was so small as fifty-six Parisian sols, it has been conjectured that they must have been illuminated prints. The Venetian decree against the importation of painted and printed figures from abroad now brings us to the country from which the chief export was made. It appears, therefore, that in the Low Countries the manufacture was carried on to a great extent; and we shall also find that in Holland and Germany, and probably over most of Europe, religion had called this art to her aid; that whilst the noble and wealthy recreated the mind and delighted the eye with the exquisite productions of the scribe and illuminator, the more humble were equally gratified with rude and simple illustrations of interesting portions of Scripture, or pictures of favourite saints. It is probable that the poorer classes hung up these drawings in their dwellings, where they excited as true and heartfelt devotion as the masterpieces of Raffaelle or Correggio in the oratories of the great. It cannot be ascertained how early this practice commenced, nor whether it preceded and suggested the printing of saints and sacred subjects, or was itself a consequence. Certain it is, that at the end of the fourteenth and the commencement of the fifteenth century the practice was very common. The impressions were taken by means of a burnisher, the gloss caused by the friction being distinctly visible on the backs both of cards and prints preserved to this time. As facility in practice increased, a distich or quotation illustrative of the print became a natural improvement; and to this was frequently added a coat of arms, the name of the saint, or the title of the subject, all in the field, or over the head of the figure; and, lastly, sometimes a date. The earliest print of which the date can be accurately ascertained, is a wood-cut of St Christopher carrying the infant Jesus across the sea. It is of folio size, and coloured in the manner of our playing-cards. At the bottom is the inscription,

Cristofori faciem die quacunque tueris — Millesimo cccc°
Illa nempe die morte mala non morieris. — xx° terno.

It was found in the monastery of Buxheim, near Meiningen, and is now in the possession of Earl Spencer.

Block-books. *Biblia Pauperum.*

The next advance was obvious. Instead of a single block, a series of blocks were employed, with additional literary illustrations; and thus were the first printed books formed. The most important of these is the *Historiæ Veteris et Novi Testamenti seu Biblia Pauperum*, truly the Poor Man's Bible. It consists of forty leaves printed upon one side of the paper only, by friction, from as many blocks; the colour is brown; the pages are placed opposite to each other, and the blank backs being pasted together, form one strong leaf. The cuts are about ten inches in height and seven and a half in width. Each print contains three sacred subjects in compartments, and four half-length figures of prophets in smaller divisions, two above and two beneath the principal subjects. Latin inscriptions are on either side of the upper figures; rhythmical verses on either side of the lower, and additional inscriptions are on labels at the bottom of the whole. The central subjects are from the New Testament, the others from the Old, and in some manner allusive to the former. There are many copies of this work, evidently from different blocks, and of different dates. Indeed it appears to have been a most popular book, and was printed repeatedly long after the introduction of legitimate printing; there are several editions in which the inscriptions are actually printed with moveable types. The exact date of these curious works is not ascertained, but Dr Horne possessed a copy contained in one volume with the *Ars Moriendi* and the *Apocalypse*, all works of the same style, the binding of which bore the date of 142( ). The original composition and design of this work is attributed, and not without some show of reason, to Ansgarius, who was bishop of Hamburg and Bremen in the ninth century. (See Plate CCCCXIII.) History.

A similar book is the *Canticles*, a small folio volume of thirty-two subjects, two being printed on each leaf, and on only one side of the paper, and the leaves also pasted back to back. It differs from the *Biblia Pauperum* in that the inscriptions are engraven on scrolls fantastically dispersed amongst the figures. This is generally allowed to be of somewhat later date than the preceding, and to hold an intermediate space between it and the *Speculum Humanæ Salvationis*, to which a larger space must be devoted, on account of its importance in the controversy relative to the invention of printing.

Speculum Humanæ Salvationis.

This is not, strictly speaking, a block-book; for whilst the form of the design and the portion of Scripture represented are engraven on wood, the inscription is in some cases engraven on wood also, but in others printed in *moveable type*. The Latin edition, *perhaps* the first, consists of sixty-three leaves, divided into five unequal gatherings. The subjects are chiefly from the Old and New Testament; but sometimes such stories have been selected from ancient history as might seem in some way appropriate to the events recorded in sacred writ. Each subject has a short Latin inscription underneath it, and the text occupies the remainder of the page. Its size is folio; the impressions are taken with a burnisher, on one side of the paper; the colour of the ink is brown, and the backs are pasted together, as in the books previously described. The work is certainly of nearly the same date, though a little later, than the *Biblia Pauperum*; and it may even have been in part executed by the same artist, for in the earlier portions there is so much general resemblance, both in design and execution, as to make it probable that the same graver was employed in both. The latter part, however, is the work of another artist; the lines are not so bold, and there is an attempt at fineness of execution, of shading, and of distance, which the earlier master did not attempt. The design, though in better drawing, is not so spirited; the drapery is more correct, though not so graceful; and in fact the engraver was a better workman, but not so great an artist. It must be understood, that there are numerous editions of this work, many differing in essential particulars, but some so nearly similar as to require a microscopic eye to detect the variations; of four of these, two are in Latin, two in Dutch, and between these four lies the contest for antiquity. Mr Ottley (whose beautiful work on Engraving contains a well-drawn-up account of his inquiry, illustrated by most convincing examples) has, from a minute and laborious examination, decided that the two Latin and two Dutch are printed from the self-same blocks, and by comparing them, and finding evidences of fractures in the one which do not exist in the other, he has very satisfactorily awarded the palm of antiquity. First, although the Latin inscriptions in the earlier part of the *first* Latin edition (so called by commentators) are engraven on blocks of wood, these blocks are not of the same piece as the figures, the work having been divided between two artists, the one more skilled in engraving figures, and the other in engraving letters. Secondly, parts of the engraving broken in the *first* Dutch are perfect in the *first* Latin; parts imperfect in the *first* Latin are unbroken in the *second* Dutch, whilst the *second* Latin is the most perfect of all; from which the conclusion is drawn that the *second* Latin is the most ancient, then the *second* Dutch, next the *first* Latin, and lastly the *first* Dutch. The printing of this work is claimed for Laurence Koster.

We have now come fairly to the practice of printing in the real sense of the word; and we have also arrived at the long-pending, long-controverted question, of who invented

History. it, and where? The honour is disputed by as many cities as contended for the birth of Homer. Only three of these can show the slightest argument for their pretensions; Harlem, Strasbourg, and Mentz. Harlem claims it for her citizen Laurence Koster, or Laurent Janszoon Koster (or Custos). The claim rests principally upon the narrative in the *Batavia* of Hadrianus Junius, a native of West Friesland, who dwelt at Harlem. The work was written in 1575, but not published until 1588. The following is a close translation of the narrative:—

Hadrian Junius's account. "There lived, a hundred and twenty-eight years ago, at Harlem, in houses sufficiently splendid (as a workshop, which remains to this day entire, can serve as proof), overlooking the forum from the neighbourhood of the royal palace, Laurentius Joannes, by surname *Ædituus*, or Custos[1] (which at that time lucrative and honourable office an illustrious family of that name, *or a family illustrious by that name*, held by hereditary right), the person who now seeks back by just avouchments and oaths the relapsing (*recidivam gloriam*) glory of the invention of printing, nefariously possessed and seized upon by others (the man), with the greatest right to be presented with greater laurel of all honours (*summo jure omnium triumphorum laurea majore donandus*). He by chance, walking in a suburban grove (as was the fashion of citizens in easy means to do after dinner in those days), began first to fashion beech-bark into letters, which being impressed upon paper, reversed in the manner of a seal, produced one verse, then another, as his fancy pleased, to be for copies to the children of his son-in-law; which when he had happily accomplished, he began (for he was of great and acute genius) to agitate higher things in his mind, and first of all devised with his son-in-law, Thomas Peter, who left four children, all of whom attained the consular dignity (a thing which I mention that all may understand the art arose in an honourable and talented, not a servile family), a more glutinous and tenacious species of writing ink, which he had commonly used to draw letters; thence (*experiretur*) he expressed entire figured pictures with characters added; in which sort I have myself seen *Adversaria* printed by him, the traces of the works (*operarum*) being only on opposite pages, not printed on both sides (*haud opistographis*). That book was in the vernacular tongue by an anonymous author, bearing for title *Speculum Nostræ Salutis:* in which it is to be observed among the first beginnings of the art (for never any is found and perfected at once), that the reverse pages being smeared with glue, were stuck together, lest they, being blank, should present a deformity. Afterwards he changed beech-blocks for lead; afterwards he made them of tin, because it was a material more solid and less flexible, and more durable: from the relics which remained of which types, very ancient wine-flasks being made, they are to this day to be seen in those houses of Laurentius which I have mentioned looking upon the forum, inhabited afterwards by his grandson Gerard Thomas, whom I name for honour's sake, a noble citizen, who departed this life a few years ago. The studies of men favouring, as it happened, the new art, since a new merchandise, never before seen, brought buyers from every side with most eager quest, at once the love of the art increased, the establishment (*ministerium*) increased, workmen in the art being added to the family, the first touch of evil; among whom was a certain Joannes, either (as the suspicion is) that Faustus of ominous name, faithless and unlucky (*infaustus*) to his master, or some other of the same name, I do not greatly care which, because I am unwilling to disquiet the shades of the silenced, touched with the plague of conscience while they lived. He being sworn by oath to the processes of printing, after he had (as he thought) learned thoroughly the art of putting the characters together, the knowledge of fusile types, and whatever else may relate to the matter, taking an opportunity, than which he could not have found one more fit, on the very eve which is sacred to the birth of Christ, on which all in common are accustomed to labour at the sacred ceremonies, stole the whole materials,[2] tied up a package of the instruments of his master used in that art (*instrumentorum herilium ei artificio comparatorum supellicticem convasat*); thence with a servant hurried from the house, went in the beginning to Amsterdam, thence to Cologne, until he arrived at Mayence, as to the altar of an asylum, where he might live safe beyond the reach of arrows (as the saying is), and having opened an office, enjoyed the rich fruit of his robberies. Indeed, from it, in the space of the (or a) turning year, in the year 1442 from the birth of Christ, with the same types which Laurentius had used at Harlem, it is certain that he produced to light the *Doctrinale* of Alexander Gallus, which grammar was then in most famous use, with the *Tractates* of Peter Hispanus, his first productions. Those are, for the most part, things which I have formerly heard from aged men worthy of belief, who have received them as things delivered from hand to hand, as a torch in a race, and have found others relating and attesting the same things. I remember that Nicholaus Galius, the instructor of my youth, a man with iron memory, and venerable for his long years, related to me, that when a boy he had heard, not once only, a certain Cornelius, a bookbinder, and rendered serious by age, nor less than eighty years old (who had lived as an under workman in that office), relating with much mental anger, and with fervour, the course of the proceeding, the manner of the invention (as he had received it from his master), the improvement and increase of the art, and other things of the kind; and that the tears would burst from him against his will at the shame of the affair, as often as he talked of the robbery. Which things do not differ from the words of Quirinus Talesius Con., who confessed to me that he had formerly the same from the mouth of the same bookbinder."

Beyond this narrative of Hadrian Junius there is little, or rather no, testimony to the truth of Koster's claim, all subsequent argument being either drawn from or referred to this statement. Many very learned bibliographers have given full credence to Hadrian, whilst others not less acute absolutely deny Koster any pretence whatever, Santander calling in question his very existence; and there is a third party who, being unable to decide between the opposing arguments, and willing to take refuge in a middle course, allow to Koster the credit of having invented printing from blocks, but assign to his rivals that of printing from moveable types.

The whole argument may, however, be reduced into a reasonable compass. The probability of Hadrian's narrative will naturally be the subject of inquiry. *First*, the roundabout way in which this hearsay evidence reached Hadrian, is in itself a very suspicious circumstance. Little belief can be accorded to an uncertain bookbinder, even had any circumstances been adduced besides the name Cornelius, by which this bookbinder could be identified. *Secondly*, Talesius was many years secretary to Erasmus, who, although a Dutchman, and resident in Holland, repeatedly and un-

[1] In the original, Koster is simply said to have been surnamed *Ædituus*, seu *Custos*, but no mention is made of the Cathedral. The statement, therefore, that he was custos of the cathedral, is a gratuitous insertion of after narrators. The word custos has been Dutchified into Coster or Koster; but there is no apparent reason why we may not suppose that *Custos* was a barbarous Latin word for keeper, or constable, or any other translation the word will bear.

[2] Or whatever else *choragium* may mean; literally it signifies the *properties* of a theatre.

History. hesitatingly ascribes the invention to John Gutenberg of Strasbourg at Mentz.[1] It is not at all probable, that had Erasmus ever heard of this story, or given the slightest credence to it if he had, he would have omitted some mention of a circumstance so gratifying to his national vanity; or that he should have remained in ignorance of a story well known to his secretary, and commonly bruited about, and therefore known to some of the learned men amongst whom Erasmus lived. *Thirdly*, the story of the engraving on beech-bark accidentally, when it is quite certain that the art of taking impressions from wood-blocks for saints and cards was at the time known and extensively practised in Holland and Germany, and also in Italy, is absurd. *Fourthly*, every author who has written upon the matter has given up all claim on Koster's behalf for the invention of cast type, the evidence in favour of others being too strong to be got over. *Fifthly*, the tale of the conversion of these types into drinking-cups, when Hadrian afterwards states that Fust carried them off with him, is incredible; for Koster's death is variously stated as having occurred in 1440 or 1442, and Hadrian says that Fust published his *Doctrinale* in 1442, within a year of his unlicensed departure; and therefore Koster could not have had time to construct the types afterwards converted into cups. *Sixthly*, the story of John Fust having stolen all his printing materials on the eve of Christmas, and decamped, first to Amsterdam, then to Cologne, and lastly to Mentz, and his publishing there within the same year, is self-contradictory; for type is not a very portable commodity; nor would he easily have escaped pursuit at Amsterdam, a town under the same government. Again, John Fust was originally no printer, but a wealthy goldsmith of Mentz, and certainly never worked as any body's journeyman. Indeed this is such a palpable misstatement, that commentators upon Hadrian have boldly supposed that the thief was John Gutenberg, not he of Mentz, but a brother, also named John. Unfortunately Gutenberg's brother was not named John, but Friele, and in no future document is there any mention of him or his father having practised the art even when known to John; nor is it at all likely that members of a noble family, and wealthy men, should have worked in the service of any man. If it should be asserted that it was *the* John Gutenberg, his time is so well accounted for that it is impossible, since he was then resident at Strasbourg, and never was at Amsterdam or Cologne. Thus, then, the narrative of Hadrian Junius appears, upon examination, to be utterly incredible, being at once at variance with itself and with all probability.

There are, moreover, other arguments not precisely resting upon this narrative; for although these circumstances are not to be believed, the main facts *may*, nevertheless, be correct. Koster *may* have printed the *Speculum* and other block-books attributed to him. Ottley says that they were certainly printed in Holland, for that the types are not those used in Germany, but closely resembled such as were afterwards cut or cast in Holland; and that they are of greater antiquity than any books printed by those who afterwards used the art in the Low Countries. He also attempts to show, by the water-marks in the paper, that the works in question were produced in these parts. Water-marks, however, and some bearing a general resemblance to these, were common in the papers used by printers of Cologne, Louvain, and elsewhere; and the argument is worth little or nothing, for no evidence can be given of the positive dates of these works, and much less of the printer. The *Speculum* was printed again and again after the invention of letter-press printing; nor is there the slightest evidence, supposing these assertions to be correct, to connect them with the name of Koster. History. It is a conclusive argument *against* him, that those other works ascribed to him and his descendants are executed with the self-same types used at Utrecht in 1473 by Ketelaer and De Leempt. Van Mander, who lived at Harlem in 1580, in his History of the Lives of Dutch Painters and Engravers, treats the claim of Harlem with contempt; for, speaking of printing, he describes it as an art "of which Harlem, with much presumption, arrogates to herself the honour of the invention;" nor does he make the slightest mention of his famous fellow-citizen.

There is not the least evidence that his *three* grandsons (not *four*, as Hadrian says) ever carried on his business; for where are their works? and in their time printers had become so proud of their art, as not only to put their names to every work, but even to add a long history of their undertaking and progress. Where are the books ascribed to them? what mention is made of them by their contemporaries? In a subsequent part of this article it will be seen that Caxton, the first English printer, is said to have been sent to Harlem to learn the art, and if possible to carry off one of the workmen. These things being also matter of controversy, cannot fairly be used in argument; nevertheless it is of some value that Caxton, who, supposing it to be true, would be an excellent witness in favour of Harlem, upon all occasions refers the invention to Gutenberg, and makes no mention whatever of Harlem or Koster.

Santander labours to disprove the very existence of any such person. But there is no necessity to go so far as Santander; we may allow Koster's identity; we may even allow that he practised the art of taking impressions from wood-blocks; but this is very different from acknowledging any claim to the invention of the art of printing. The most strenuous champion of Koster is Meerman, an eminent French bibliographer of the last century, who, in his *Origines Typographicæ*, published at the Hague in 1765, strongly maintains this narrative of Hadrian; which is not a little singular, seeing that the Newcastle Typographical Society published a letter from him to Wagenaar, of eight years prior date, in which he expresses a precisely contrary opinion. He calls Seitz's (Hadrian's) story a mere supposition, and the chronology a romantic invention; gives to the *Speculum* the date of 1470 as the earliest possible; attributes the honour to Gutenberg, and incidentally mentions his intention of publishing a pamphlet on the subject. Notwithstanding this, in his work, without any new fact whatever, he accredits Hadrian's story, finds consistency in the dates, believes the *Speculum*, and denies John Gutenberg; completely reversing his previous opinion, though, by changing the predicates, his narrative may still stand. The *Divisiechronyk*, in 1517, places printing amongst foreign discoveries.

All evidence, and the general consent of the learned, in failure of Koster, unhesitatingly ascribe this invention to

John Gutenberg, surnamed Genzfleisch, Gensfleisch, or Gensefleisch, von Solgenloch, or Sorgenloch. He was a native of Mentz, and of a noble family, possessed of considerable property in various places in the neighbourhood. Fortunately the life of Gutenberg does not rest merely upon hearsay evidence, or the doubtful guesses of bibliographers from dateless wood-cuts; legal documents supply most important information. It appears that, for some reasons unknown, he resided for many years at Strasbourg, and had even acquired rights of citizenship. The first document presents him in no amiable light. It is a lawsuit instituted to compel him to perform his marriage-contract with Anne von Isernen Thür; and it would appear that he was compelled to make good his promise, the name of Anne Gutenberg Gutenberg.

[1] Anno Christi 1440. Magnum quoddam ac pene divinum beneficium collatum est universo terrarum orbi, a Johanne Gutenberg Argentinensi, novo scribendi genere reperto. Is cum primus artem impressoriam, quem Latini vocant *excusoriam*, in urbe Argentinensi invenit; inde Moguntiam veniens eandem feliciter complevit. (*Epit. Rerum Germ. Script.* 1502, cap. 95.)

History. being found in the same register of the nobility liable to the wine-duty in the city of Strasbourg, in which Gutenberg's name also appears. The next document is so curious that an ample abstract of it cannot but be interesting.

It appears that he had contracted an engagement with Andrew Dritzehen, John Riffe, and Andrew Heilmann, to instruct them in the secrets of certain arts, and had entered into partnership with them for their better advantage. Andrew Dritzehen and Andrew Heilmann having called upon him one day, perceived that he was engaged in a wonderful and unknown art, the secret of which he was desirous of keeping to himself; that, moved by their importunities, he consented to enter into partnership with them for the term of five years, on two conditions, first, that they should pay him the sum of 250 florins, 100 immediately, and the remainder at a certain fixed period; second, that if any one of the partners should die during the term of the copartnership, the survivors should pay to his heirs the sum of 100 florins, in consideration of which the effects should become the property of the surviving partners. Andrew Dritzehen died before the expiration of the period agreed on, being still indebted to Gutenberg in the sum of eighty-five florins. George and Nicholas, brothers of the deceased, demanded to be admitted to the partnership, and on refusal brought an action against Gutenberg as principal partner. The magistrates gave judgment on the 12th of December 1439, relieving Gutenberg from the demand upon payment of the sum of fifteen florins, being the difference of the sum of 100 florins stipulated to be paid to the heirs of a deceasing partner, and the sum of eighty-five florins due to Gutenberg by Andrew on the original contract. The following evidence was produced on the trial :—

"Anna, the wife of John Schultheiss, an engraver on wood, deposed, that on one occasion Nicholas Beildeck came to her house to Nicholas Dreizehen, her relation, and said to him, 'My Nicholas Dreizehen, Andrew Dreizehen, of happy memory, has placed four pages (*stücke*) in a press, which Gutenberg has desired that you will take away and separate, that no man may know what they are, for he is unwilling that any one should see them.'

"Also John Schultheiss says, that Laurence Beildeck sometime came to his house to Nicholas Dreizehen, when Andrew Dreizehen his brother was dead, and that the said Laurence Beildeck thus spoke to said Nicholas Dreizehen: 'Andrew Dreizehen, of happy memory, has placed four pages on a press, which John Gutenberg desires you to take therefrom, and place them on the press and break them from one another, so that no man may see what they are.'

"Also Conrad Sahspach deposed, that sometime Andrew Heilman came to him upon the Street of Merchants and said, 'My Conrad, as Andrew Dreizehen is dead, and you made that press, and know all about the matter, go hence and take the pieces from that press and lay them separate from one another, so that no man may know what it is.'

"Laurence Beildeck says that he was sent by John Gutenberg to Nicholas Dreizehen, after the death of Andrew his brother, to say to him that he should show to no one the press that he had, and that he should see to it. He added, that Gutenberg had moreover commanded him that he should go suddenly to the presses, and open that press which was furnished with two *screws* or spindles (*cochleis*), that the pages should fall into pieces, and place those pieces within or upon the press, so that no one should see the matter, or understand what it was.

"The same witness also said that he knew well that Gutenberg, a little before the feast of the Nativity, had sent his servant to both Andrews to take away all forms, which were broken up in his sight, that none of them might be found perfect. Moreover, after the death of Andrew, this witness was not ignorant that many were desirous of seeing the presses, and that Gutenberg had commanded that some one should be sent who might hinder any one from seeing the presses, and that his servant was sent to break them up. History.

"Also John Dunne, goldsmith, said, that three years or thereabouts previous he had received from Gutenberg about 300 florins for materials relating to printing."

From this curious document may be learnt, that separate types were used; for if they were blocks arranged so as to print four pages, how could they be so pulled to pieces that no one should know what they were, or how could the abstraction of two screws cause them to fall to pieces? It appears that some sort of presses were used, and the transfers no longer taken by a burnisher or roller; and, lastly, that the art was still a great secret at the time when Koster was at the point of death. Hence it is manifest, that the ingenuity of Gutenberg had made a vast advance from the rude methods of the time, and had in fact invented a new and hitherto unknown art.

These documents would be decisive in favour of Strasbourg as the place in which printing was invented, had it appeared that any effects were produced by this establishment. This, however, does not seem to have been the case, as Gutenberg and his successors make no mention of the fact, but, on the contrary, claim for themselves the production of the first book at Mentz. Indeed the partnership appears to have expired without any attempt at entering into fresh engagements; for, about the year 1450, Gutenberg returned to his native city with all his materials, without any opposition from his partner. In this place he entered into partnership with John Fust, a wealthy goldsmith and citizen, who engaged, upon being taught the secrets of the art, and being admitted into a participation of the profits, to advance the necessary funds; and he did accordingly advance the considerable sum of 2020 florins, a fact that completely overthrows the fable of his having been one of Koster's workmen, and of his having stolen his types. The new partnership immediately commenced operations, and hired a house called Zum Jungen, and took into their employ Peter Schœffer and others. Their subsequent operations we again find curiously chronicled in the records of another lawsuit,[1] in which Gutenberg was soon engaged with his new ally; for Fust, dissatisfied with their proceedings, sought to recover from Gutenberg money advanced, with interest, including 800 florins of the sum advanced in virtue of the deed of partnership. Gutenberg in defence alleged, that the 800 florins had not been paid at once, as stipulated; and that they had been expended in preparation for the work (apparently meaning thereby, that this sum of money should have been paid down for his own use, in consideration of his communicating the secrets of his art, and that instead of so applying it to his private purposes, he had expended it for the joint benefit); whilst, as to the other sums, he offered to give an account of their appropriation, but denied that he was liable for the interest. The judges awarded that Gutenberg should pay the interest, as well as the part which his accounts showed he had applied to his individual use. This decision took place on the 6th of November 1455. Upon this Fust obtained from the public notary the following document:

"To the Glory of God, Amen. Be it known unto all those who shall see or hear read this instrument, that in the year of Our Lord 1455, third indiction, on Thursday the sixth day of November, the first year of the Pontificate of our very Holy Father the Pope, Calixtus III., appeared here at Mayence, in the great parlour of the Bare-footed Friars, between eleven o'clock and mid-day, before me, the Notary,

[1] Wolfii *Monumenta Typographica.* Fournier, *Origine de l'Imprimerie.*

History. and the undersigned witnesses, the honourable and discrete person, James Fust, citizen of Mayence, who, in the name of his brother, John Fust, also present, has said and declared clearly, that on this same day, and at the present hour, and in this same parlour of the Bare-footed Friars, John Gutenberg should see and hear taken by John Fust an oath, conformable to the sentence pronounced between them. And this sentence read in the presence of the honourable Henry Gunter, Curé of St Christopher of Mayence, of Henry Keffer, and De Bechtoff de Hanaw, servant and valet of the said Gutenberg; John Fust, placing his hand upon the Holy Evangelists, has sworn between the hands of me, the Notary Public, conformable to the sentence pronounced, and to a letter which he has sent to me, and has taken the following oath, word for word: I, John Fust, have borrowed 1550 florins, which I have transmitted to John Gutenberg, which have been employed for our common labour, and of which I have payed the rent and annual interest, of which I still owe a part. Reckoning, therefore, for each hundred florins borrowed, as above is recited, six florins per annum, I demand of him the repayment and the interest, conformably to the sentence pronounced; which I will prove in equity to be legal, in consequence of my claim upon the said John Gutenberg. In presence of the honourable Henry Gunter, of Henry Keffer, and of Bechtoff de Hanaw aforesaid, John Fust has demanded of me an authentic instrument, to serve him as much and as often as he hath need, in the faith of which I have signed this instrument, and have set thereto my seal."

From this it would appear (indeed the mortgage of his printing materials to Fust, mentioned in this document, proves) that Gutenberg had expended the whole of his considerable private fortune in his experiments, and had fallen into the power of his more wealthy associate; for in consequence of this judgment, and owing probably to his being unable to repay the sums demanded, the whole of his materials, constructed with so much perseverance, fell into Fust's hands; for the initial letters used by Gutenberg and his partners, in works known and supposed to have been executed between 1450 and 1455, are likewise used by Fust and Schœffer in the Psalter of 1457 and 1459. After such a mortifying result of so many years' labour, it would have been no matter for wonder had Gutenberg abandoned the unprofitable pursuit. On the contrary, he appears to have immediately started anew with fresh vigour, and this time with success. Another legal document gives curious information.

"We, Henne (John) Genszfleisch de Sulgeloch, named Gudinburg, and Friele Genszfleisch, brothers, do affirm and publicly declare by these presents, and make known to all, that, with the advice and consent of our dear cousins, John, and Friele, and Pedirmann Genszfleisch, brothers, of Mentz, we have renounced and do renounce, by these presents, for us and for our heirs, simply, totally, and at once, without fraud or deceit, all the property which has passed by means of our sister Hebele, to the convent of St Claire of Mentz, in which she has become a nun, whether the said property has come to it on the part of our father Henne Genszfleisch, who gave it himself, or in whatsoever manner the property may have come to it, whether in grain, ready money, furniture, jewels, or whatever it may be, that the respectable nuns, the abbess, and sisters of the said convent, have received in common or individually, or other persons of the convent (have received), from the said Hebele, be it little or much; and we have promised and do promise, by these presents, in good faith, for us and for our heirs, that neither we, nor any person on our part, nor yet our said cousins, nor any of their heirs, nor any person on their part, shall either demand, gain, nor claim of the said convent, nor of the abbess, nor of the convent in general, nor of the persons who may be found therein individually, the said property, of whatever kind it may be, either wholly nor in part, and History. that we will never demand it again, either through an ecclesiastical or civil court, or without the aid of the law; and that neither we nor our heirs will ever molest the said convent, either by words or deeds, either secretly or publicly, in any manner. And as to the books, which I, the said Henne, have given to the library of the convent, they are to remain there always and for ever; and I, the said Henne, propose also to give in future, without disguise, to the library of the said convent, for the use of the present and future nuns, for their religious worship, either for reading or chaunting, or in whatever manner they may wish to make use of them according to the rules of their order, *all the books which I, the said Henne, have printed up to this hour, or which I shall hereafter print, in such quantities as they may wish to make use of;* and for this the said abbess, the successors and nuns of the said convent of St Claire, have declared and promised to acquit me and my heirs of the claim which my sister Hebele had to the sixty florins, which I and my said brother Friele had promised to pay and deliver to the said Hebele, as her portion and share arising from the house which Henne, our father, assigned to him for his share, in virtue of the writings which were drawn up thereupon, without fraud or deceit. And in order that this may be observed by us and by our heirs, steadfastly and to its full extent, we have given the said nuns and their convent and order these present writings, sealed with our seals. Signed and delivered the year of the birth of J. C. 1459, on the day of St. Margaret."

From this it will appear, that his new establishment had actually produced the long wished-for effect. He appears to have carried on the business ten years; for in 1465 he entered into the service of Elector Adolphus of Nassau, as one of his band of gentlemen pensioners, with a handsome salary, as appears from the letters patent, dated the 17th January 1465, and finally abandoned the pursuit of an art which, though it caused him infinite trouble and vexation, has been more effectual in preserving his name and the memory of his acts, than all the warlike deeds and great achievements of his renowned master and all his house. Gutenberg died on the 24th of February 1468. His printing-office and materials had passed into the hands of Conrad Humery, syndic of Mentz, who had probably assisted him with money, and who appears to have been in some degree his partner. He afterwards sold them to Nicholas Bechtermunze of Elfield, whose works are greatly sought after by the curious, as they afford much proof, by collation, of the genuineness of the works attributed to his great predecessor.

There does not appear to be any record of the early life Fust and Schœffer. of JOHN FUST or PETER SCHŒFFER before their partnership with Gutenberg, save that the former was a wealthy goldsmith and an ingenious man, and that Schœffer, surnamed de Gernsheim, was a scribe. It is very likely that the combination of character and qualifications of these three men may afford a good clue to the wonderful taste and beauty which distinguish the works issued from their press, and consequently to the great general improvement of the art during their life. The ingenuity of Gutenberg would readily suggest a new and expeditious method of manufacturing types; the practical skill of Fust as a worker in metals (and the working in gold and silver had at that time attained a most extraordinary nicety and beauty), and his large pecuniary resources, would readily supply the necessary appliances, while the taste of Schœffer would give all possible grace and beauty to the new forms. For Schœffer, it must be recollected, was a scribe, one of the ancient and honourable craft whose occupation was destined to fall before the new art; a transcriber, perhaps an illuminator, of the manuscript works in use before printed books; and those who have had the happiness of viewing those exquisite specimens of skill which beguiled our ancestors into study and

History. devotion (when will modern typography produce such feasts for mind, and eye, and imagination?) will readily conceive that Schœffer's eye was already schooled for the conception, and his hand for the execution, of all the beauty the trammels of a new art and limited skill would allow. Aided by his own taste and his partners' invention and wealth, Schœffer proceeded to a new enterprise, namely, the *casting* of type. The entire conception and execution of this invention has been generally attributed and allowed to Schœffer. It seems most probable, however, that where three ingenious men are bound together by art and interest, no one of them can lay exclusive claim to any invention or undertaking executed in the workshops and for the mutual benefit of all. Allowing, therefore, to Schœffer the honour of having suggested some such plan, the other two may fairly put in a claim for their portion of the credit on the score of their suggestion and assistance, especially since Fust, as a worker in metals, would have been the party to engage workmen to elaborate the conceptions of his partners' brain. Accordingly the only evidence upon the subject appears to show that the firm had for some time practised a method of taking casts of type in moulds of plaster; for it must be remembered that the types of Gutenberg's earlier efforts, both at Strasbourg and at Mentz, were cut out of single pieces of wood or metal with infinite labour and imperfection. The method of casting, however, although a great improvement, was at best but a slow and tedious process. Every new letter required a new mould; no skill or care could enable the workman to impress so small a thing as a type is at the face, yet so elongated in the shank, fully, freely, and steadily, into a soft material; and it would be necessary afterwards, under the most favourable circumstances, that the squareness and sharpness so indispensable in type should be given by another slow process, so that at best this advance was but an imperfect and tedious operation. Schœffer has therefore an undoubted claim to be considered as one of the three inventors of printing; for he it was who first suggested the cutting of punches, whereby not only might the most beautiful form of type the taste and skill of the artist could suggest be fairly stamped upon the matrix, but a degree of sharpness and finish quite unattainable in type cut in metal or wood could be given to the face; whilst to the shank, by the very same process by which the face was cast, the mould would give perfect sharpness and precision of angle. Add to this, that the punch being once approved of, could be kept ready to stamp a new matrix in precisely the same condition and form as the first, should that be worn out or mislaid, or make a duplicate should the demands of business require it. It is nevertheless rather singular, that the mould represented on the right side of the press of Ascensius, shortly after the time of Schœffer, should be precisely the same in form and manner of use as that of the present day. This was evidently an immense stride towards perfection; let Schœffer therefore take a place on the right hand of the inventor.

Within eighteen months of their separation from Gutenberg, Fust and Schœffer produced the celebrated Psalter. This was printed with large cut type. As it was impossible to prepare a new fount and print this splendid work in that short space, it must be evident that the partners did great injustice to Gutenberg in suppressing his name from the colophon. This book was produced in the month of August 1457, and is the first book which bears the name of the place where it was printed, those of its printers, and the date of the year in which it was printed. The first book, however, bearing date, was issued by Fust and Schœffer in 1455, viz. the *Literæ Indulgentiarum Nicholai V.*; it is on a single piece of parchment. This Psalter was reprinted in 1459, 1490, and 1502, and always in the same type, which, it is remarkable, was never used for any other work, probably because its great size made it unfit for any other works than those not intended for popular reading, but to lay on desks like our church Bibles. On the 16th of October 1459, Fust and Schœffer published the *Durandi Rationale Divinorum Officiorum*, with an entirely new fount of type; in 1460 the *Constitutiones Clementis V.*; and in 1462 the celebrated Latin Bible. Fust enjoyed this successful and glorious practice of his art but ten short years; yet in this period what an immense advance from the misshapen and irregular lumps of their first efforts, ugly in themselves, and more ugly in their utter want of relative proportion and allignement, to the well-proportioned, evenly standing type of the Bible! The plague carried him off in Paris about the year 1466, full of years, and perchance full of honours. Schœffer survived many years, and, in conjunction with Conrad Henlif, produced a great number of works. His name is found in the colophon of the fourth edition of the Bible of 1502, about which time he is supposed to have deceased.

Were we to take tradition for our guide as regards the character of Fust, we should regard him as a conjurer and an adept in the black art. The popular story (and many "grave and discrete old men" have given credit to the tale) runs, that having kept these proceedings profoundly secret, as soon as their Bible was finished, Fust transferred himself to Paris with many copies of the new work, and palmed them upon the learned as manuscripts, to which, as they were printed on vellum, in a type bearing much resemblance to the written books of the period, and the vignettes and initial letters were splendidly illuminated, they were not very dissimilar; that some eager scholar or devotee became the possessor of the first copy, supposing it to be a rare chance, at the moderate price of four or five hundred crowns; that as he brought the work into the market, the price fell rapidly to sixty, and then to thirty crowns, by which time the extraordinary glut produced suspicion, and Fust was accused of multiplying Holy Writ by the aid of the devil, and was accordingly persecuted by the priesthood, whilst the laity, looking to their temporal interests, prosecuted him for his inroad into their pockets; and that from these things Fust was obliged to quit Paris precipitately. The whole story is an impossible fabrication.

Having thus given a sketch of the origin and history of the art of printing, a brief account of the works issued by the illustrious triumvirate will not only be proper here, but will give the general reader a better idea of the astonishing perfection to which the art rose under the taste and genius of its inventors. There is not a single work of Gutenberg which bears his name; yet, as before remarked, there are several which bear such internal evidences, that the literati of all parties and opinions are unanimous in attributing them to his press.

Of these works, Dr Dibdin, the well-known bibliographer, gives the following account:

"First, as to the *character of the type* used by the early Mentz printers. This appears to have been uniformly what is called *Gothic;* and if we except the varieties of the larger type (from three eighths to two eighths or to a quarter of an inch), which appear in the Psalters of 1457, 1459, and 1490 (the type common to most works executed about the same period), we shall observe three distinct sets or forms of letters used in the printing-office of Faust and Schoiffher. Of these three typographical characters, two only (if we except the one with which the Bible of 1455 was executed) are visible in the publications which appear to have been printed in the lifetime of Faust; that is to say, the larger Gothic used in the Bible of 1462, and the smaller Gothic in the Offices of Cicero, of the dates of 1465 and 1466. These appeared united, the former, for the first time, in the *Constitutions of Pope Clement V.*, of the date of 1460. Schoiffher introduced a type of an intermediate size, which may be seen, among other works, in the *Rudi-*

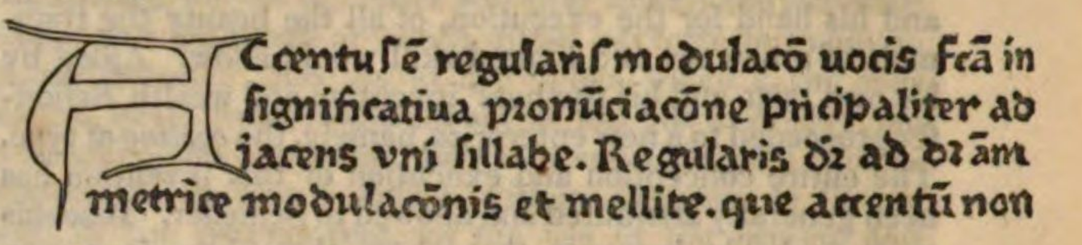
History. *ments of Grammar* of 1468, and in the *Decretals of Pope Gregory the Ninth*, of the date of 1479. This intermediate type is of a narrower form, and prints very closely. Of the three types here mentioned, the largest is undoubtedly of the handsomest dimensions; but they all partake of the *Secretary Gothic*, and may be said to be the model of that peculiar character which was adopted by the early Leipsic printers, Thanner and Boëttiger, and was more especially used by John Schoiffher and the other German printers for nearly the whole of the sixteenth century. Shew me Lisardo, one book, nay, one leaf only, printed in the *Roman type*, in the colophon of which the name of Faust or of Peter Schoiffher appears, and you shall immediately have the amount of the balance in my favour, at my banker's, be it great or small, be it L.200 or L.20, for such a precious and unheard-of curiosity.

"We shall now, in the second place, say a few words as to the *character of the printing*, or of the *mechanical skill*, of the early Mentz press. There can be but one opinion upon this point. Everything is perfect of the kind, the paper, the ink, and the register, or regularity of setting up the page. The Bible of the supposed date of 1455 is quite a miracle in this way;[1] but the Psalters are not less miraculous, nor is less praise due to the *Constitutions of Pope Clement V.*, of the date of 1460, and the *Bible* of 1462; while the *Durandus*, of the earlier date of 1459, exhibiting the first specimen of the smallest letter, strikes one as among the most marvellous monuments extant of the perfection of early typography. Almost all the known works before the year 1462 are printed *upon vellum*, doubtless because they ventured upon limited impressions; and even of the Bible of 1462 more copies have been described upon vellum than upon paper. Upon the whole, the vellum used by Faust and Schoiffher, although inferior to the Venetian, is exceedingly good, being generally both white and substantial.

"In the third place, let us notice the nature or character of the works which have issued from the press of Faust and Schoiffher. Whatever may be our partiality towards that establishment from which the public were first gratified with the sight of a printed book, candour obliges us to confess that the fathers of printing were not fortunate, upon the whole, in the choice of books which issued from their press.

"In the fourth place (for I told you I should be somewhat tautologous), consider what is the typographical appearance of those books which Gutenberg is really supposed to have executed. It is quite unique. A little barbarous, and certainly wholly dissimilar from any thing we observe in other contemporaneous productions of the Mentz press. You will please to understand that I think very doubtfully of the *Donatuses*, which are considered to have been printed by him; as well as of the *Speculum Sacerdotum*, and *Celebratio Missarum;* concluding the *Catholicon* of 1460, and the *Vocabularies* of 1467 and 1469, to be the more genuine productions of his press, or of the types used by him. Is it not surprising, I ask, that these works are executed in types quite different from anything we observe in the Mentz productions? and this from a man who is considered as the parent of printing in that city. No wonder, if they *be* the actual productions of Gutenberg, that Faust and Schoiffher thought so meanly of his talents, and that on a dissolution of partnership they adopted a different and a very superior character."

In confirmation of these remarks of the learned bibliographer, we shall here insert a specimen of Gutenberg's *Balbus de Janua*, which will also be a curious illustration of ancient art. Notwithstanding the appearance of these types, the reader is assured that the original is really printed from separate pieces of metal.[2] History.



Dr Horne, in the appendix to his Introduction to Bibliography, says of the Psalter, "This precious work, as Santander justly calls it, is one of the most known among early printed books, from the various and correct descriptions of it which have been given by different bibliographers. Until the discovery of Pope Nicholas' *Literæ Indulgentiarum*, this was supposed to be the very first article ever printed with a date affixed; the book is executed on vellum, and of such extreme rarity that not more than six or seven copies are known to be in existence; all of which, however, differ from each other in some respect or other. The most perfect copy known is that in the imperial library at Vienna; it comprises 175 leaves, of which the Psalter occupies the 135 first and the recto of the 136th. The remainder is appropriated to the litany, prayers, responses, vigils, &c. The psalms are executed in larger characters than the hymns, similar to those used for missals prior to the invention of printing; but all are distinguished for their uncommon blackness. The capital letters, 288 in number, are cut on wood with a degree of delicacy and boldness which are truly surprising; the largest of these, the initial letters of the psalms, which are black, red, and blue, must (as Lichtenberger has remarked) have passed *three times* through the press. Copies are now in the Queen's library at Windsor, and in that of Earl Spencer at Spencer House." A facsimile of the initial B, and a portion of the first verse of this beautiful book, and of the colophon at the end, will be found in Plate CCCCXIV.

The extraordinary praise awarded by these eminent bibliomaniacs to the first productions of the Mentz press may perchance excite in the minds of the more sober public a suspicion that these writers have been led away by their enthusiasm beyond the limits of matter-of-fact truth, and have seen merit in defects, beauty in deformity, and lustre in antiquity. Assuredly, nevertheless, such is by no means the case; and the happy individual who gains access to the *chef-d'œuvres* of Fust and Schœffer will return from the inspection a wiser man; for the beauty of these works is inconceivable. England fortunately possesses several of these treasures of art, there being copies of the Bible of the supposed date of 1450-55 in the Royal Library, in the Bodleian, and in those of Earl Spencer and Sir M. Sykes; whilst of the six known copies of the Psalter of 1457, two are in England, namely, one at Windsor, and one in the possession of Lord Spencer. Of the Latin Bible of Fust and Schœffer, 1462 (the first bearing date), there are copies *on vellum* at Blenheim, in the libraries of Lord Spencer, the Earl of Jersey, and Sir M. Sykes, in the British Museum, and imperfect in the Bodleian. Copies *on paper* are rarer still, there being but three in this country, viz. those in the Royal Library and the British Museum, and one lately in the possession of Mr Willett.

Apparently, in retaliation of the injustice done to Gutenberg by his partners in depriving him of any share of

[1] This is even sober praise. The mechanism of the press-work, and appearance of the ink, beautiful, regular, and glossy as the whole appears, does not strike one with more astonishment than the manufacture of the paper. "Charta," says Tungendres, "ejusdem est crassitudinis, qualem illo tempore libris imprimendis consumere mos fuit." And again, "Charta ob ejus densitatem atque spissitudinem haud ingratam ubique se maxime commendat." (*Disq. de Not. Charact. Libror.* p. 27, p. 46.) And see Meerman's testimony in favour of the paper of the Soubiaco press, *Orig. Typog.* vol. i. p. 9, note.

[2] The initial A is illuminated in a very brilliant blue. The reader who is desirous of obtaining the full effect of this specimen can fill up the printed outline in water-colour.

History. the honour of producing the Psalter of 1457, which, as before stated, must be the joint production of all three, although it was not finished until after the secession of Gutenberg, bibliographers have generally agreed in attributing the printing of the Bible of 1450-55 to Gutenberg alone, when it is equally manifest that Fust and Schœffer had as much claim to the honour as their coadjutor. It is an exceedingly beautiful book, in two very large folio volumes, in two columns, containing from forty-one to forty-three lines each, in very large well-cut types. It consists of six hundred and forty-one leaves; it has no title, paging, signatures, or catch-words; the initial letters are not printed, but painted in by illuminators, and the initial letters of each verse of the psalms are painted alternately red and black, by way of guide to the priests in their alternate reading. From the lustre and blackness of the ink, its evenness of colour, and beautiful execution, it is a very superb book; but it is nevertheless surpassed by the Fust and Schœffer edition of 1462, when they had attained greater experience in the practice of the art. By far the choicest, however, of these *editiones principes* is the Mentz Psalter or *Codex Psalmorum* before mentioned, the initial B and first few lines of which form part of Plate CCCCXIV. Dr Horne says that the six known copies of this edition differ from each other in some respects, and proceeds to give some particulars in which variations are found; but, upon a comparison of the royal copy with Earl Spencer's, it will be found, that although they bear the same date, they are in fact two distinct editions. It would have excited no great surprise had it been found that the printed ornaments differed, as nothing would be more easy than to change the colours with which the different blocks were worked; but the text varies in such a manner that there can be no doubt of their perfect distinctness. By comparing the following terminations of the lines of the Windsor copy with the specimen, this will be clear. The first line of the Windsor copy ends with abiit; the second with the contracted et; the third with stetit; the fourth with non; the fifth with uni; the sixth with lege. This will be found to arise from a difference in the contractions of the following words:

	Windsor Copy.		Earl Spencer's Copy.
First line	q̄	instead of	qui;
Second line,	consilio	instead of	ꝯsilio;
Third line,	pec̄or nō	instead of	pecatorm̄ non;
Fourth line,	ī	instead of	in;
Fifth line,	nō	instead of	non.

These differences arise apparently from the desire of so apportioning the words that each line shall be completely justified out in the Windsor copy, which (as may be seen in the plate) is not the case in Lord Spencer's copy; from which circumstance it is probable that the latter is the earliest. The book[1] is a very large folio, on vellum, consisting of about a hundred and thirty leaves, printed on both sides. There are generally twenty-three lines in a page, in Gothic type. Every psalm begins with a splendid initial letter, about two thirds of the size of the B, *printed* in two colours in almost every case. Occasionally, however, this appears to have been neglected, and then the letter is painted in by the illuminator, but *not* in imitation of the printed letters. The initials consist (like the B) of a bold character, of Gothic cut, surrounded by a scroll, which is sometimes of great length, that of the B extending from the top to the bottom of the page. The same wooden block is used as often as the letter occurs, but it is not always of the same colour; moreover, every *verse* commences with a smaller initial printed in a red colour, in the same manner as the ꝑ in the specimen. Nor is this work destitute of the embellishments of the illuminator; for at the commencement of every psalm is a rubric, painted in a most brilliant red, in a smaller letter, of precisely the same character as the text, and also the music of the chant, with the words underneath it painted in black. The initial letters of both are splendidly illuminated in various colours. The paint is used in such profusion that the letters are absolutely in relief, often to the extent of one sixteenth of an inch; and besides these, the letter following the grand initial has a broad bar painted down it, and very frequently the first letter after the pauses indicated in our authorized version by a colon is illuminated in a similar manner. One page is particularly splendid; it consists of short verses, in which the first words are constantly repeated. It commences with a grand initial, and there are twenty-two smaller initials to the verses; the second letter of the first verse, and the first letter after every pause (twenty-three in number), having the broad illuminated bar. Wherever the psalm commences too near the bottom to allow of the full exuberance of the scroll, a piece of paper appears to have been laid over a portion of the cut, to prevent the impression from appearing; and in one psalm where the chant is of unusual length, the lower part of the initial O, and a corresponding portion of the scroll, are thus suppressed; the music being illuminated in its place, and the scroll continued below it. Sometimes the illuminator has omitted to add his initial letter; and in this copy the double device is omitted. The accuracy with which the coloured blocks are printed within the text and within each other is perfectly astonishing. From this description it may be conceived how very superb is the *first* book ever printed, the date, and place, and artist, of which can be accurately ascertained. Dr Dibdin in the *Bibliotheca Spenceriana*, Mr Savage in his work on *Decorative Printing*, Dr Horne, whose wood-block is not coloured, and several other writers, have given fac-similes of the same copy (Lord Spencer's), which, however, all differ from one another. The lines given in the specimen in Plate CCCCXIV. are copied from Dibdin, whose initial B does not accord with that of the Windsor copy; the B here given is very accurate, and the colours are as similar as possible to the latter copy, but the colour of the scroll in the original seems somewhat faded.

History.

The capture of the city of Mentz by Count Adolphus of Nassau in the year 1462 had the effect of interrupting the labours of Fust and Schœffer; and moreover the distracted state of the city enabled, perhaps compelled, the workmen initiated in the mysteries of the art to flee into the neighbouring states, and thus spread its practice over the whole civilized globe. Such, indeed, was the fame it had already acquired, and such the idea entertained of its importance, that every community with the slightest pretensions to literature appears to have sought a knowledge of it with the greatest avidity. Thus, within six years of the publication of the Psalter, it had spread to several cities having some connection with Mentz, and within fifteen years to almost every town of consideration in Christian Europe. A chronological list of the cities which first seized upon the invention would be greatly too long for this article; it may be interesting, however, to extract a few of the principal, with a notice of such printers as are remarkable either for the beauty or the scarcity of their works. The reader is not to suppose that all, or indeed any great number of these, learned the practice of the art under the tuition of the first masters. A few are known to have been pupils of the inventors, and it is probable that many others of them were so; but the majority, in all likelihood, were men of learning, enterprise, or capital, who derived their typographical knowledge from such facts as had transpired, or from inferior

Early printers.

[1] The copy described is that at Windsor: the illuminations, no doubt, vary in every copy.

History. workmen of Fust and Schœffer or Gutenberg, supplying deficiencies by their own ingenuity.

Strasbourg. Mentelin. Some writers have claimed for Mentelin the invention of printing, representing that Gutenberg was his servant, without, however, showing the slightest ground for their assertions; but others, more reasonable, say that he was acquainted with Gutenberg, and instructed by him, and that on the latter's quitting Strasbourg he established a printing-office, and carried on the business successfully. Mentelin most probably printed about the year 1458. His type is rude and inelegant. The only book bearing his name is Beauvais' *Speculum Historiale*, of date 1473. Schæpflin says, that he, as well as Fust and Schœffer at Mentz, printed 300 sheets per day.

In 1461. *Bamberg.* Albert Pfister. He printed a collection of *Fables*, of date 1461. This book is excessively rare; it is printed with cast metal type, and is illustrated with 101 wood-cuts, in much the same style as the old *Biblia Pauperum.* All his other works are printed in the same type.

1465. *Subiaco* and *Rome.* Schweynheym and Pannartz. Their known works are, a *Donatus*, without date; Lactantius, 1465; St Augustin on *the City of God*, 1467; Cicero *de Oratore*, without date; and the *Commentary of De Lyra on the Bible*, 1471, all in folio. These works were printed in a new letter, very closely resembling the type now in use called *Roman*, and of which they were the introducers. In *De Lyra* are the earliest specimens of Greek types worthy of the name; some few letters appear in the *Cicero de Officiis* printed at Mentz, but so wretchedly imperfect that they are unworthy of mention. It is curious that the Greek fount of Schweynheym and Pannartz at Subiaco was evidently very small; but upon their removal to Rome they cast a much larger fount. The cut and appearance of this Greek is more than respectable. There is a very curious petition from them to the pope, praying for assistance on the ground that they had entirely ruined themselves by printing *De Lyra*, for which there was no sale, and representing that they had on their hands no less than eleven hundred folio volumes of that work. Subiaco is the first place in Italy in which printing was practised. At Rome Ulric Han and Lignamine were contemporaries. Their works, particularly those of Han, are excessively rare.

1467. *Elfield.* Henry and Nicholas Bechtermunze. They purchased from Conrad Humery the types and materials of Gutenberg. Their works are not at all remarkable for beauty, but are very rare, and much sought for as affording evidence of Gutenberg's works.

1467. *Cologne.* Ulric Zell. His type is Gothic, and of no beauty; but his works are rare.

1468. *Augsburg.* Ginther Zainer printed the first book in Germany with Roman type.

1469. *Venice.* John de Spira, whose works are of the utmost beauty. His edition of Pliny is splendid, and enormous sums have been given for those printed in vellum. He did not use Greek characters; but Greek passages are composed in Roman types. In the same city, at the same time, printed Nicholas Jenson, whose works are equal, if not superior, to those of Spira; they are not so rare, but are almost equally sought after. A copy of his folio Latin Bible of 1479, printed in Gothic type, was sold at Mr Edwards' sale for L.115. 10s. Venice was also the residence of Christopher Valdarfar, whose works gave rise to a most extraordinary event connected with bibliography, viz. the sale of the first edition of *Il Decamerone di Boccaccio*, printed by him in 1471. For many years it had been known that a single copy of this work was in existence, and the most devoted bibliomaniacs had used their utmost endeavours to discover it, but in vain. At length, about 1740, an ancestor of the Duke of Roxburghe obtained possession of it for the sum of one hundred guineas. In lapse of time it became the property of John duke of Roxburghe, the accomplished, indefatigable, and undaunted bibliomaniac, after whose death the gorgeous library was dispersed by the auctioneer in the year 1811. The interest excited amongst the learned by this sale was intense. It was known that the collection contained the most superb specimens of every kind of ancient lore; that the illuminated manuscripts were the most brilliant, the ballads the most obscure, the *editiones principes* the most complete that the world could produce; that the rarest Caxtons, the finest Pynsons, and grandest specimens of the foreign printers, were here to be found; above all, it was rumoured that a mysterious edition of Boccaccio's Decameron would become a bone of contention amongst the noblest of the literati. The public, learned and unlearned, were infected with the mania, and the daily papers teemed with notices of the sale. At length the important day arrived, the 17th of June 1811. St James' Square was the place. Mr Evans presided. The room was crowded; Earl Spencer, the Marquis of Blandford, the Duke of Devonshire, and an agent of Napoleon, were amongst the most prominent. The book was a small folio, in faded yellow morocco binding, black-letter. "Silence followed his (Mr Evans') address," says Dibdin. "On his right hand, standing against the wall, stood Earl Spencer: a little lower down, and standing at right angles with his lordship, appeared the Marquis of Blandford. The duke, I believe, was not then present; but my Lord Althorpe stood a little backward, to the right of his father Earl Spencer. Such was 'the ground taken up' by the adverse hosts. The honour of firing the first shot was due to a gentleman of Shropshire, unused to this species of warfare, and who seemed to recoil from the reverberation of the report himself had made. 'One hundred guineas,' he exclaimed. Again a pause ensued; but anon the biddings rose rapidly to five hundred guineas. Hitherto, however, it was manifest that the firing was but masked and desultory. At length all random shots ceased, and the champions before named stood gallantly up to each other, resolving not to flinch from a trial of their respective strengths. 'A thousand guineas' were bid by Earl Spencer; to which the marquis added 'ten.' You might have heard a pin drop. All eyes were turned; all breathing well nigh stopped. Every sword was put home within its scabbard, and not a piece of steel was seen to move or to glitter save that which each of these champions brandished in his valorous hand. See, see; they parry, they lunge, they hit; yet their strength is undiminished, and no thought of yielding is entertained by either. 'Two thousand pounds' are offered by the marquis. Then it was that Earl Spencer, as a prudent general, began to think of an useless effusion of blood and expenditure of ammunition, seeing that his adversary was as resolute and fresh as at the onset. For a quarter of a minute he paused, when my Lord Althorpe advanced one step forward, as if to supply his father with another spear for the purpose of renewing the contest. His countenance was marked with a fixed determination to gain the prize, if prudence in its most commanding form, and with a frown of unusual intensity of expression, had not bade him desist. The father and son for a few seconds converse apart; and the biddings are resumed. 'Two thousand two hundred and fifty pounds,' said Lord Spencer. The spectators are now absolutely electrified. The marquis quietly adds his usual 'ten,' and there is an end of the contest. Mr Evans, ere his hammer fell, made a due pause, and, indeed, as if by something preternatural, the ebony instrument seemed itself to be charmed or suspended 'in mid air.' However, at length down dropped the hammer, and, as Lisardo has not merely poetically expressed himself, 'the echo' of the sound of that fallen hammer 'was heard in the libraries of Rome, of Milan, and Saint Mark.' Not the least surprising incident of this extraordinary sale is, that the marquis already possessed a copy of the work, which History.

History. wanted a few leaves at the end; he therefore paid this enormous sum for the honour of possessing a few pages. The prize of this contest is now in the possession of Earl Spencer."

1469. *Milan.* Lavagna. In 1476 Dionysius Palavasinus printed the Greek Grammar of Constantine Lascaris, in quarto, which is the first book printed entirely in Greek. The first printing in Hebrew characters was performed at Soncino, in the duchy of Milan, in 1482.

1470. *Paris.* Ulricus Gering, M. Crantz, and M. Friburger.

1471. *Florence.* Bernard Cennini. In 1488 Demetrius of Crete printed the first edition of Homer's works, in most beautiful Greek.

1474. *Basle.* Bernardus Richel.

1474. *Valencia.* Alonzo Fernandes de Cordova.

1474. *Louvain.* Joannes de Westphalia.

1474. *Westminster.* William Caxton, the Game of Chess.

1475. *Lubeck.* Lucas Brandis.

1476. *Antwerp.* Thierry Martins of Alost.

1476. *Pilsen* in Bohemia. *Statuta Synodalia Pragensia;* printer's name not known.

1476. *Delft.* Maurice Yemantz.

1478. *Geneva.* Adam Steinschawer.

1478. *Oxford.* Theodericus Rood.

1480. *St Albans. Laurentii Guillielmi de Saona Rhetorica Nova;* printer's name not known.

1482. *Vienna.* John Winterburg.

1483. *Stockholm.* Johannes Snell.

1483. *Harlem. Formulæ Novitiorum,* by Johannes Andriesson. This is the earliest book printed at Harlem *with a date.* In giving this as the first work *known* to be printed at Harlem, the claims of Koster, his grandsons and successors, must, of course, be reserved.

1493. *Copenhagen.* Gothofridus de Ghemen.

1500. *Cracow.* Joannes Haller.

1500. *Munich.* Joannes Schobzer.

1500. *Amsterdam.* D. Pietersoen.

1507. *Edinburgh.* A Latin Breviary; no printer's name. From a patent of James IV. it appears that the first printing press was established at Edinburgh in 1507. From the style and types, it is probable that they were imported from France.

1551. *Dublin.* Ireland was apparently the last country in Europe into which printing was introduced. The first book printed is a black-letter edition of the Book of Common Prayer, printed by Humphrey Powell.

1569. *Mexico.* Antonio Spinoza, *Vocabulario en Lengua Castellana y Mexicana.*

1639. *United States,* at the town of Cambridge. Printer Stephen Daye.

It was the custom of the early printers to distinguish their books by the most fantastic devices; and by these their works may be readily recognised. Many of them were of exceeding beauty, and all the skill and appliances of their art were employed to render them striking; they are really an ornament to their works. The invention of these has been ascribed to Aldus; but the very first printers, Fust and Schœffer, used each for himself, yet conjoined, devices of rare excellence. Their celebrated Bible is adorned with one which is well worthy of being adopted as the arms of the art and mystery of printing. This is given in the plate of illustrations with those of Caxton, Wynkyn de Worde, and Pierre Regnault, who, with his brother, printed the first English Testament at Paris.

Our chronological arrangement has precluded us from mentioning some of the most skilful typographers. Their works, however, are so numerous, and their efforts so well known, as to render it unnecessary to do more than mention their names. Such men as the Aldi, Frobenius, Plantinus, Operinus, the Stephani, the Elzeviri, the Gryphii, the Giunti, the Moreti, and hosts of peers, have universal fame. The printing-office of Plantinus, in the Place Vendredi, at Antwerp, exists in its full integrity, and in the possession and use of his descendants the Moreti; the same presses, the same types, with the addition of every improvement modern skill has effected, are still in use, and an inspection of these singular relics of olden art will well repay the investigation of the curious. History.

The First Presses.

Of the mechanical means by which these beautiful impressions of the old printers were produced there is little or no record; but it is quite evident that they must have been effected by some more skilful process than mere manipulation, that is, than the appliance of a burnisher, as is evident in the first wood-cuts, or of a roller, or superficial pressure applied immediately by hand. It is very probable that one of the difficulties which Gutenberg found insuperable at Strasbourg, was the construction of a machine of sufficient power to take impressions of the types or blocks then employed; nor is it at all wonderful that the many years he resided at that city were insufficient to produce the requisite means; for, with cutting type, forming his screws, inventing and making ink, and the means of applying his ink when made, his time must have been amply occupied. Moreover, the construction of a press would require a versatile genius, and excellent mechanical skill, not to be looked for in one man. But upon his junction with Fust and Schœffer, the gold of the former, and the invention of all the three, would soon supply the defect; and, for aught that appears to the contrary, the press used in their office differed in no essential point from those in use until the improvements of Blaew in 1600–20. Fortunately, amongst the queer devices with which it pleased the earlier printers to distinguish their works, Badius Ascensius of Lyons (1495–1535) chose the press; and there are cuts of various sizes on the title-pages of his works. It appears from these, that, like that of Gutenberg, they could print only four pages at a time, and that at two pulls; and when it is stated that the table and tympan ran in, and that the platten was brought down by a powerful screw, by means of a lever inserted into the spindle, the professional reader will easily recognise the wooden presses laid up in ordinary in many old London houses.

The colour which the earliest typographers used was probably made according to the style of work in hand. The earliest copies of the *Speculum* and *Biblia Pauperum* were printed in a brown colour, of which raw umber is the principal ingredient. It appears to have been well ground and thin. It was, most likely, of the same tint as the old drawings of the same subjects, and would be better adapted for the filling up in various colours, as appears to have been the practice, than a black and harsh outline of ink. Fust and Schœffer, however, introduced, and their followers adopted, black ink, and were so skilful in compounding it that their works present a depth and richness of colour which excites the envy of the moderns; nor has it turned brown, or rendered the surrounding paper in the slightest degree dingy. From the above-mentioned colophons we have also the method of applying it to the types. This was by means of balls of skin stuffed with wool, in every respect the same as those used thirty years ago. The ink was laid in some thickness on a corner of a stone slab, and taken thence in small quantities and ground by a muller, and thence again taken by the balls and applied to the types. The types appear to have been disposed in cases very much the same as ours. The composing-stick differs somewhat, but cannot now be very clearly made out. The different operations of casting the type, composing, reading, and working, are mostly represented in the same apartment; but, it is probable, more for the sake of pictorial unity, than because such

History. was really the custom. There must have been many workmen engaged in most of the old establishments; and they well knew the value of cleanliness, which is unattainable where all the operations are carried on together.

Introduction into England.

As the invention of printing has itself become matter of serious controversy amongst the learned of all countries, its introduction into England has not been suffered to pass without an attempt of the novelty-seekers to overturn the received opinion on the subject. and to give to another the laurel of a public benefactor, torn from him to whom the general voice had for two centuries allotted it. Fortunately, the quarrel is divested of one of the great difficulties of the continental, inasmuch as there does not appear to be any vestige of an art in any degree similar (such as block-printing) having been practised prior to the introduction of type-printing; the art, when it was brought over, being in a state somewhat approaching maturity. This controversy concerns the claims of William Caxton and Frederic Corsellis to the introduction of the knowledge of the art, and the printing of the first book, in this country.

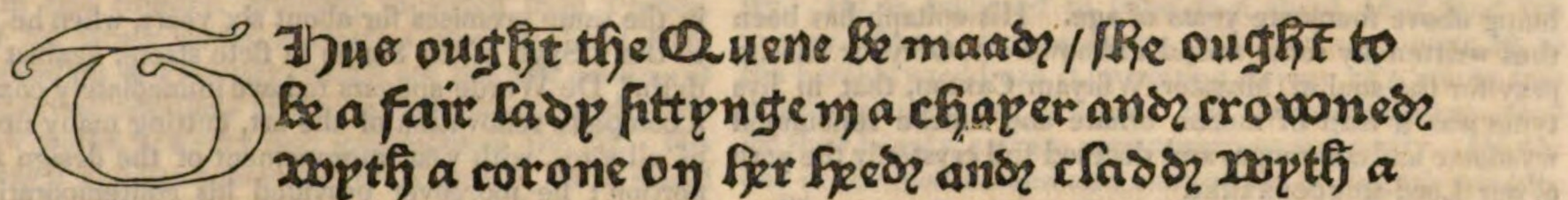
The general and original belief is that Caxton, who for thirty years resided in the Low Countries, under the reign of Charles the Bold, and who had taken every opportunity of learning the new art, and had availed himself of the capture of Mentz to secure one of the fugitive workmen of Fust and Schœffer, established a printing-office at Cologne, where he printed the French original and his own translation of the *Recuyell of the Historyes of Troy;* that whilst at Cologne he became acquainted with Wynkyn de Worde, Theoderick Rood, both foreigners, and Thomas Hunte his countryman, who all subsequently became printers in England; that he afterwards transferred his materials to England; that Wynkyn de Worde came over with him, and probably was the superintendent of his printing establishment; that his first press was established at Westminster, perhaps in one of the chapels attached to the abbey, and certainly under the protection of the abbot; and that he there produced the first book printed in England, the *Game of Chess*, which was completed on the last day of March 1474.

The correctness of these facts is not matter of dispute, all writers agreeing that Caxton did so set up his press at Westminster, and print his *Game of Chess* in 1474; but it has been asserted that Caxton was not the first printer, nor his book the first book printed, in this country. Neither does the controversy rest upon the contradictory statements of many writers, for all authors of the same and succeeding period agree in ascribing the honour to Caxton; and when, in 1642, a dispute arose between the Stationers' Company and certain persons who printed by virtue of a patent from the crown, concerning the validity of this patent, a committee was appointed, who heard evidence for and against the petitioners, and throughout the proceedings Caxton was acknowledged as incontestibly the first printer in England. Thus Caxton seemed to be established as the first English typographer, when, soon after the Restoration, a quarto volume of forty-one leaves was discovered in the library at Cambridge, bearing the title of *Exposicio Sancti Jeronymi in Simbolum Apostolorum ad Papam Laurentium*, and at the end, "Explicit Exposicio Sancti Jeronymi in Simbolo Apostolorum ad papam Laurentium, Oxonie Et finita, Anno Domini M.CCCC.LXVIII. *xvii.* die decembris." Upon the production of this book the claim for priority of printing was set up for Oxford. In the year 1644 Richard Atkyns, who then enjoyed a patent from the crown, and whose claims consequently brought him into collision with the Stationers' Company, and who was desirous of establishing the prerogative of the sovereign, published a thin quarto work, entitled *The Original and Growth of Printing, collected out of the History and the Records of the Kingdome; wherein is also demonstrated that Printing appertaineth to the Prerogative Royal, and is a Flower of the Crown of England.* The book was published "*by order and appointment of the Right Hon. Mr Secretary Morrice.*" History.

In support of this proposition Atkyns asserted that he had received from an anonymous friend a copy of a manuscript discovered at Lambeth Palace, amongst the archiepiscopal archives. The following is an abstract of this document. "Thomas Bouchier, archbishop of Canterbury, earnestly moved the king, Henry VI. to use all possible means to procure a *printing* mold, to which the king willingly assented, and appropriated to the undertaking the sum of 1500 merks, of which sum Bouchier contributed 300. Mr Turnour, the king's master of the robes, was the person selected to manage the business; and he, taking with him Mr William Caxton, proceeded to Harlem in Holland, where John Guthenberg had recently invented the art, and was himself personally at work; their design being to give a considerable sum to any person who should draw away one of Guthenberg's workmen. With some difficulty they succeeded in purloining one of the under workmen, Frederic Corsellis; and it not being prudent to set him to work in London, he was sent under a guard to Oxford, and there closely watched until he had made good his promise of teaching the secrets of the art. Printing was therefore practised in England before France, Italy, or Germany, which claims priority of Harlem itself, though it is known to be otherwise, that city gaining the art from the brother of one of the workmen, who had learned it at home of his brother, and afterwards set up for himself at Mentz." The *Exposicio* is asserted by inference to be the work of Corsellis. That this document is a forgery may be safely assumed; because of the more than unsatisfactory manner in which it is said to have been obtained; because no one ever saw this copy; because no one, except the unknown, ever saw the original, for it is not amongst the archives nor in the library of Lambeth Palace, nor was it when the Earl of Pembroke made diligent search for it in 17( ), nor was it found when the manuscripts, books, and muniments were moved into a new building; because Caxton himself, who took so important a share in the alleged abduction of the workman, states that twelve years afterwards he was diligently engaged in learning the art at Strasbourg, and repeatedly ascribes the invention to Gutenberg, "at Mogunce in Almayne;" because, when three years afterwards the Stationers' Company instituted legal proceedings against the University of Cambridge, to restrain them from printing, this document was rejected, as resting only on Atkyns' authority; because Archbishop Parker, in his account of Bourchier, mentions the invention of printing at Mentz, but makes no claim for his having introduced it into England, and Godwin, *de Præsulibus Angliæ*, says that Bourchier, during his primacy of thirty-two years, did nothing remarkable, save giving L.120 for poor scholars, and some books to the university, and that he minutely examined two registers of his proceedings during this term, without making any mention of his having found therein any record of so remarkable a transaction; because, since these transactions must have taken place before 1459, Henry VI. was at that time struggling fearfully for his throne and life, Edward IV. being crowned in that year; from internal evidence of the document itself, for, not to mention the weak evidence for the city of Harlem, it is quite certain that Gutenberg never printed there, and by Junius the theft is ascribed to John Fust, who certainly was a rich goldsmith of Mentz; whereupon Meerman, finding these statements at variance with possibility, boldly invents another theory, making the sufferers Koster's grandsons, who never printed, as far as is known, and the robber Corsellis himself; and, lastly, because six years elapsed between this asserted introduction and the publication of his *Exposicio*, and eleven years between this and any other publication from any Oxford press

History. Although these facts entirely confute the pretensions of Corsellis, there nevertheless remains the book itself, and unless some evidence can be produced, Oxford will still maintain the proud pre-eminence. Some of the most learned bibliographers entirely refuse their assent to the genuineness of the book. Middleton asserts that there must be an error of an x in the imprint, and produces many remarkable instances of similar typographical errors. This, however, is mere assertion; and as, in the Lambeth record, the best evidence is to be sought in the production itself, accordingly the work is printed with *cast* metal types, which are not proved to have been used by Koster at all, that art being invented by Gutenberg, Fust, and Schœffer at Mayence. The letter is of very elegant cut, the pages regular, and the whole work has the appearance of having been executed at a considerably advanced era of the art. Another and a good argument is, that the work has signatures, or marks for the binder at the foot of the page, such not having been used on the continent before 1472, by John Koethof at Cologne; and it is no refutation of this argument to say, as has been attempted by some, that many works executed by printers who did use signatures are without signatures; for the proof of a negative in one case is the poorest of all possible arguments of a positive in another. Let Caxton, therefore, be replaced in his old niche, the introducer of the art of printing into England.

Caxton. WILLIAM CAXTON was born about the year 1412, in the Weald of Kent. His father was a wealthy merchant, trading in wool. He was brought up to the business of a mercer, and conducted himself so much to his master's satisfaction, that on his death he bequeathed him the then considerable sum of twenty marks. Caxton then proceeded, History. probably as the agent of the Mercers' Company, into the Low Countries. He must have been a man of some wealth and consideration, for in 1664 he and Richard Wethenhall were appointed by Edward IV. "ambassadors and special deputies" to continue and confirm a treaty of commerce between him and Philip duke of Burgundy; and, upon the marriage of Edward's sister Margaret with Charles duke of Burgundy, he was appointed to the household retinue of the princess, by whom he appears to have been treated with much familiarity and confidence; for at her instigation he first commenced his literary labours, and he mentions her as repeatedly commanding him to amend his English. His first work was a translation of the *Recuyell of the Historyes of Troye*, which he afterwards printed at Strasbourg, when his leisure had allowed him to turn his attention to the study of printing. The first production of his press is allowed to be the French *Recuyell* above mentioned, his second the *Oracion of John Russell on Charles Duke of Burgundy being created a Knight of the Garter*, which took place in 1469. Of his transactions between 1471 and 1474 there is no record; probably he was engaged in the diligent pursuit of the art, and preparing to transfer his materials to England, which he accomplished some time before 1477, when we find him printing in or near the Abbey of Westminster, of which Thomas Milling, bishop of Hereford, was at that time abbot. The first production of his English press was the *Game of Chess*, bearing date 1474, which work, however, some assert to have been printed by him at Cologne. The following is a specimen of this famous book, the initial letter being printed in red:



His next production was the *Boke of the hoole lyf of Jason;* but his first book bearing date and place in the colophon is the *Dictes and Sayings of Philosophres*, a translation from the French by the gallant Earl Rivers, "at Westmestre, the yere of our lord M. CCCC. lxxvij." From this time he continued both to print and translate with great spirit. His "capital work" was a *Book of the noble Historyes of Kyng Arthur*, in 1485, the most beautiful production of his press.

There is but one copy of any of Caxton's works printed upon vellum; it is the *Doctrinal of Sapyence*. "Translated out of Frensshe in to Englysshe by wyllyam Caxton at Westmestre. Fynyshed the vij day of May the yere of our lord M.CCCC.lxxix. Caxton me fieri fecit." This unique copy is in the library at Windsor, and it is in beautiful preservation. It is moreover doubly unique, for it contains an additional chapter, to be found in no other copy whatever, and which is entitled "Of the negligencies happening in the Masse and of the Remedies. Cap. lxiiij." It is a curious treatise of minute omissions and commissions likely to occur in the service of mass, with directions how to remedy such evils. Of their importance here are two specimens, "If by any negligence fyl (fall) any of the blood of the Sacrament on the *corporas*, or upon any of the vestments, then ought to cut off the piece on which it is fallen, and ought well to be washen, and that piece to be kept with the other relics." "And if the body of Jesu Christ, or any piece, fall upon the palé of the altar, or upon any of the vestments that ben blessed, the piece ought not to be cut off on which it is fallen, but it ought right well to be washen, and the washing to be given to the ministers for to drink, or else drink it himself." This singular treatise finishes with this grave confession, "This chapitre to fore I durst not sett in the booke, by cause it is not convenient ne appertaining that every lay man should know it et cetera." At the usual termination of this work is that colophon of Caxton which is given amongst the illustrations of this article in Plate CCCCXIV.; it is, however, considerably reduced.

The Royal Library possesses another work of Caxton, which, as a *perfect* copy, is also unique. This is the "Subtyl Historyes and Fables of Esope. Translated out of Frenshe in to Englyshe by Wyllyam Caxton at Westmynstre In the yere of our lord M CCCC lxxxiij Emprynted by the same the xxvj daye of Marche the yere of our lorde M CCCC lxxxiiij And the fyrste yere of the regne of kyng Rycharde the thyrde." It consists of 142 leaves. Each fable is illustrated by a rude wood-cut, all of which are said to have been executed abroad, where similar editions of Æsop were frequently printed. They are, however, most probably copied; for there is nothing either in their design or execution that a most moderate artist might not perform; and this will equally apply to other wood-cuts interspersed in Caxton's works.

It has been said that the works of Caxton have been eagerly sought for by English bibliomaniacs. The most remarkable instances of this are the enormous prices given for some of them at the sale of the Duke of Roxburghe's library before mentioned. The *Chastysing of God's Children* was knocked down to Earl Spencer for L.146. The *Sessions Papers* were bought for the Society of Lincoln's Inn for L.378. The Duke of Devonshire gave L.351. 15s. for *The Mirrour of the World*, and L.180 for

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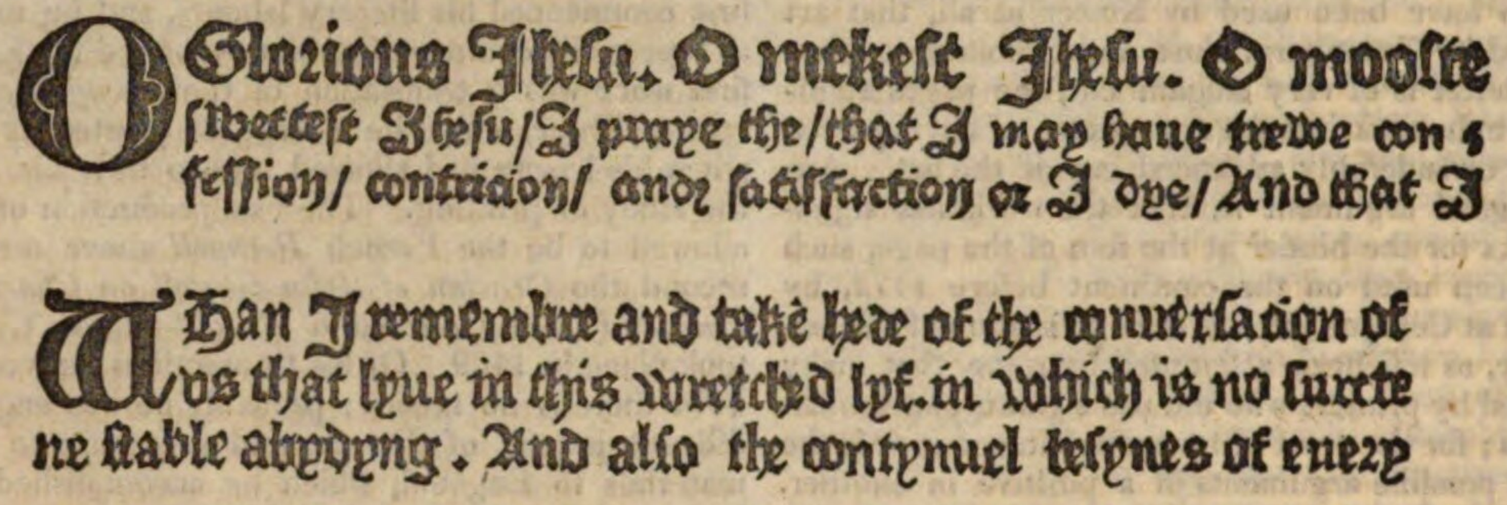
the *Kalendayr of the Shyppers*. Gower's *Confessio Amantis* produced L.366; *The Boke of Chyvalry*, L.336. The *Recuyell of the Historyes of Troye* gave rise to a startling contest. It was the identical copy presented by Caxton to Elizabeth Grey, queen of Edward IV. and sister of his patroness. "Sir Mark Sykes vigorously pushed on his courser till five hundred guineas were bidden; he then reined in the animal, and turned him gently on one side 'toward the green sward.' More hundreds are offered for the beautiful Elizabeth Grey's own copy. The hammer vibrates at nine hundred guineas. The sword of the marquess is in motion, and he makes another thrust—'One thousand pounds.' 'Let them be guineas,' said Mr Ridgway, and guineas they were. The marquess now recedes. He is determined upon a retreat; another such victory as the one he has just gained (the Valdarfar Boccaccio) must be destruction; and Mr Ridgway bears aloft the beauteous prize in question." (Dibdin.) At Mr Willett's sale *Tullius of Old Age* produced L.210, and became the property of the Duke of Devonshire.

History.

The following are specimens of Caxton's *Pilgrimage of the Sowle*, and of the *Royal Book*:



He must have been a man of wonderful perseverance and erudition, cultivated and enlarged by an extensive knowledge of books and the world. Of his industry and devotedness some idea may be formed, when Wynkyn de Worde, his successor, states, in his colophon to the *Vitæ Patrum*, that Caxton finished his translation of that work from French into English *on the last day of his life*. He died in 1494, being above fourscore years of age. His epitaph has been thus written by some friend unknown: "Of your charite pray for the soul of Mayster Willyam Caxton, that in hys tyme was a man of moche ornate and moche renommed wysdome and connynge, and decesed full crystenly the yere of our Lord MCCCCLXXXXI.

Moder of Merci shyld him from thorribul fynd,
And bryng hym to lyff eternal that neuer hath ynd."

The type used by Caxton is in design very inferior to that used upon the Continent even earlier than his period; but in the latter part of his life he very materially improved his founts, and some of his later productions are very elegantly cut. The design is peculiar to him, and is said to be in imitation of his own hand-writing; it bears, however, some resemblance to the types of Ulric Zell, from whom Caxton derived most of his instruction, and is something between *Secretary* and *Gothic*. He appears to have had two founts of *English*, three founts of *Great Primer*, one *Double Pica*, and one *Long Primer*.[1] He used very few ornamented initial letters, and those he did employ are very inferior in elegance to those of foreign printers. He preferred inserting a small capital letter within a large space, and leaving the interval to be filled up according to the taste of the illuminator, owing to which many excellent performances are destitute of these beautiful ornaments. Caxton's ink was not remarkable for depth of colour or richness; his paper was excellent; and he probably used presses of the same construction as the continental printers. His works are not very rare, but are highly prized by English collectors. Copies of one or more of his works are to be found in most collections of any pretension, and are well worthy of inspection. The number of his productions is sixty-two. Although Caxton was the first English printer, he was not the only one of his day, Wynkyn de Worde, Lettou and Machlinia, Hunte, Pynson, the Oxford printer whoever he may have been, and he of St Alban's, being his contemporaries.

Wynkyn de Worde

Wynkyn de Worde came, as we have already seen, from Germany with Caxton, and remained with him in the superintendence of his office until the day of his death, when he succeeded to the business. He was a native of Lorraine, and evidently a man of considerable information and taste, and of great spirit in the conduct of his affairs. After his succession to Caxton's business, he carried it on in the same premises for about six years, when he removed to the "Sygn of the Sonne in flete strete, against the condyth." De Worde appears to have immediately commenced a complete renovation of the art, cutting many new founts of all sizes, with vast improvement of the design and proportion; he moreover provided his contemporaries, then becoming very numerous, with type; and it is even said that some of the letter used by English printers less than a century ago are from his matrices, nay, that the punches are still in existence. He was the first (or Pynson) to introduce Roman letters into England, which he made use of amongst his Gothic to distinguish any thing remarkable, in the same manner as Italic is used in the present day. His works amount to the extraordinary number of four hundred and eight. "His books are, in general, distinguished by neatness and elegance, and are always free from professed immorality. The printer has liberally availed himself of such aid as could be procured from the sister art of engraving; although it must be confessed that by far the greater, if not the whole, number of wood engravings at this period are of foreign execution; nor is it without a smile that the typographical antiquary discovers the same cut introduced into works of a directly opposite nature."

In his *Instruction for Pilgrims to the Holy Land*, printed in 1523, the text of which is in Roman, and the marginal notes in Italics, he makes the first use in England of Greek, which is in moveable type; of Arabic and Hebrew, which are cut in wood; and the author complains that he is obliged to omit a third part, because the printer had no Hebrew types. Appended to the work are three Latin epistles, in which he makes use of Arabic.

His works are, of course, not so rare as those of his predecessor, but are nevertheless much sought after; and, when sold by the side of the Caxtons at the Duke of Roxburghe's sale, produced large prices. *Bartholomæus de Proprietatibus Rerum*, the first book printed on paper made in England, was bought by the Duke of Devonshire for L.70. 7s.

[1] These are terms by which modern English printers distinguish the sizes of their type.

History. Chaucer's *Troylus and Cresseide*, L.43; Hawys' *Exemple of Vertu*, L.60; *Passetyme of Pleasure*, L.81; *Castell of Pleasure*, L.61; *The Moste Pyteful Hystorye of the Noble Appolyon, Kynge of Thyre*, L.110.

De Worde died about the year 1534. In his will, still in the Prerogative Office, dated 5th June 1534, he bequeaths many legacies of books to his friends and servants, with minute directions for payment of small creditors and forgiveness of debtors, betokening a conscientious and kindly disposition. His device is generally that of Caxton, with his own name added to the bottom; but he also used a much more complicated one, consisting of fleurs-de-lis, lions passant, portcullis, harts, roses, and other emblazonments of the later Plantagenets and the Tudors. A fac-simile of the former will be found in Plate CCCCXIV.

Lettou. JOHN LETTOU and WILLIAM MACHLINIA printed separately and jointly before the death of Caxton, but were very inferior to him in every respect; their type being most especially barbarous. Their works are not very numerous, and are principally upon legal subjects; they printed the first edition of Lyttleton's Tenures.

Pynson. RICHARD PYNSON was a Norman by birth, and studied the art of printing under his "worshipful master William Caxton." It would seem that he was an earlier printer than Wynkyn de Worde, having established an office before the death of Caxton. His first work is of date 1493, and was printed "*at the Temple-bar of London.*" He enjoyed high patronage, and was appointed by Henry VII. to be his printer before 1503. He is perhaps inferior to De Worde as a typographer, his first types being extremely rude. He afterwards used a fount of De Worde's, and another peculiar to himself in this country, probably imported from France. Some of his larger works, Fabian's Chronicle, Lord Berner's translation of Froissart (which are the first editions of these important additions to English literature), and some of his law-works, are very fine specimens of the art. His device was a curious compound of R and P, on a shield which is sometimes supported by two naked figures.

Early English printers. Of Julian Notary, William Faques, Henry Pepwell, and others, it is unnecessary even to mention their names, inasmuch as they add little that is interesting to the history of English typography.

Grafton. RICHARD GRAFTON, however, claims especial notice. He was by trade a grocer, although of good family. Of his education nothing appears; but he was one of the most voluminous authors of his time, having, by his own account, written a considerable portion of Hall's Chronicles, an Abridgment of the Chronicles of England, and a Manual of the same, a Chronicle at Large, and other books of historical character, under what circumstances is not known. In 1537 Grafton published Thomas Mathew's translation of the Bible, which was printed abroad, but where is not satisfactorily ascertained; and in 1538 the Testament translated by Miles Coverdale, which was printed at Paris by Francis Regnault. At this time it would not appear that English printers were in high estimation; for Lord Cromwell, desirous of having the Bible in the English language, thought it necessary to procure from Henry VIII. letters to the king of France for license to print it at Paris, and urged Bonner to tender his earnest assistance. Bonner entered upon the undertaking with such zeal, that in recompense he was soon afterwards appointed to the bishopric of Hereford. Miles Coverdale had charge of the correctness (see his letter, Gent.'s Mag. 1791), and Richard Grafton and Edward Whitchurch were the *proprietors;* but under what arrangement does not appear. When the work was on the point of completion, the Inquisitors of the Faith interfered, seized the sheets, and Grafton, Whitchurch, and Coverdale, were compelled to make precipitate flight. The avarice of the lieutenant-criminal induced him to sell the sheets for waste paper instead of destroying them, and they were in part repurchased. The Testament was intrusted to Francis Regnault, whose brother used the tasteful colophon which will be found in Plate CCCCXIV. Under the protection of Cromwell they next, after many difficulties, obtained their types and other materials from Paris, and the Bible was completed at London in 1539. "Thus they became printers themselves, which before this affair they never intended." The edition consisted of 2500 copies. Cromwell next procured for them a privilege (not an exclusive one, however) for printing the Scriptures for five years. Very shortly after the death of Lord Cromwell, Grafton was imprisoned for printing Mathew's Bible and the Great Bible, his former friend Bonner much exaggerating the case against him. The prosecution, however, was not followed up; but in a short time he was, with Whitchurch, appointed printer to Prince Edward, with special patents for printing all church-service books and primers. The document is curious. It recites that such "bookes had been prynted by strangiers in other and strange countreys, partely to the great losse and hynderance of our subjects, who both have the sufficient arte, feate and treade of prynting, and partely to the setting forthe the bysshopp of Rome's usurped auctoritie, and keping the same in contynuall memorye;" and that, therefore, of his "grace especiall, he had granted and geven privilege to our wel-biloved subjects Richard Grafton and Edward Whitchurch, citezeins of London," exclusive liberty to print all such books for seven years, upon pain of forfeiture of all such books printed elsewhere.

One Richard Grafton, supposed to be the above, was member of parliament for the city of London in 1553–54, and also in 1556–57, and in 1562 was member for Coventry. He is supposed to have died about 1572, and not in very affluent circumstances. He used a punning, or, as the heralds would call it, a canting device, of a young tree or *graft* growing out of a *tun*. His works are distinguished for their beauty, and are very numerous and costly. He was one of the most careful and meritorious of English printers.

These are the titles of a few of his early Bibles, &c.

The Byble, 1537, folio. "The Byble, which is all the holy Scripture: In whych are contayned the Olde and Newe Testament truly and purely translated into Englysh by Thomas Mathew. Esaye 1 ☞ Hearcken to ye heauens, and thou earth geaue eare: For the Lorde speaketh. M.D.XXXVII." The title of the New Testament is, "The newe Testament of our sauyor Jesu Christ, newly and dylygently translated into Englyshe, with Annotacions in the Mergent to help the Reader to the vnderstandyng of the Texte." This was printed in France.

The New Testament, Latin and English. 1538. Octavo. "The new testament both in Latin and English after the vulgare texte; which is red in the churche. Translated and corrected by Myles Couerdale: and prynted in Paris, by Fraunces Regnault. M. cccc. xxxviii in Nouembre. Prynted for Richard Grafton and Edward Whitchurch. cytezens of London. Cum gratia & priuilegio regis."

The Byble in Englysshe. 1539. Folio. "The Byble in Englyshe, that is to saye the content of all the holy Scrypture, bothe of ye olde, and newe testament, truly translated after the veryte of the Hebrue and Greke textes, by ye dylygent studye of dyuerse excellent learned men, expert in the forsayde tongues. *Prynted by Rychard Grafton, and Edward Whitchurche. Cum priuilegio—solum.* 1539." This is a very superb book, and is the one which was commenced at Paris and finished at London under the circumstances before related.

NEWE TESTAMENT IN ENGLYSSHE. 1540. Quarto. "Translated after the texte of Master Erasmus of Roterodame."

THE PRYMER. English and Latin. 1540. Octavo.

THE BYBLE IN ENGLYSHE. 1540. Folio. A noble volume, called, from the preface, Cranmer's Byble.

History. THE BYBLE IN ENGLYSHE. 1541. Folio. "The Byble in Englyshe of the largest and greatest volume, auctorised and appoynted by the commaundement of oure moost redoubted prynce and soueraygne Lorde, Kynge Henrye the VIII, supreme head of this his churche and realme of Englande: to be frequented and vsed in euery Churche within this his sayd realme, accordyng to the tenoure of hys former Jniunctions geuen in that behalfe. Ouersene and perused at the cōmaundemēt of the kynges hyghnes, by the ryght reuerend fathers in God Cuthbert byshop of Duresme, and Nicholas, bisshop of Rochester." The lines of the title are printed alternately red and black.

Such, with many other manuals, primers, &c. were the productions of this most eminent British typographer.

John Day. JOHN DAY was a printer of much eminence; and his works are numerous, beautiful, and useful.

Isaac Jaggard, Edward Blount, &c. The first complete edition of Shakspeare's Plays was printed by ISAAC JAGGARD and EDWARD BLOUNT, in folio, in 1623. Of his single plays, the earliest is "The first part of the Contention betwixt the two famous Houses of Yorke and Lancaster," which was printed by "THOMAS CREED for Thomas Millington, and are to be sold at his shop, under Saint Peter's Church, Cornwall" (Cornhill), in 1594. These plays were printed by various typographers, amongst whom appear the names of George Eld, Valentine Simmes, R. Young, John Robson, and others who only give their initials.

Peter Parker. The first edition of Milton's Paradise Lost was printed in quarto by PETER PARKER in the year 1667; the Paradise Regained in 1671.

During the troublesome times that preceded the great rebellion, the Puritans, jealously watched and persecuted, introduced the anomaly of ambulatory presses, which were constantly removed from town to town to escape the vigilance of the Star-Chamber. At these presses many of Milton's controversial pamphlets were printed; and it is even said that the identical press at which the Areopagitica was printed is still in existence, and was lately in the possession of Mr Valpy, the well-known printer of the Variorum Classics.

It is a very pleasing reflection, that the earlier practitioners of the art did, by their uniform good character and religious turn, tend much to render their profession productive of a highly moral class of literature, and to raise it in the estimation of all men. Had they been less respectable, had they turned their attention to the many ribald and tasteless writings of those times, the effect of the new art would have been to degrade literature and lower morals, to delay the spread of knowledge, and to give a depression to the character of the art and its practitioners, from which possibly they might never have recovered. These excellent and learned men appear to have received their temporal reward, in public estimation, sufficient wealth, and a length of years beyond the ordinary term of mortality.

Oxford. Setting aside the claim of Corsellis, printing was first practised at OXFORD by Theoderic Rood and Thomas Hunte from 1480 to 1485. In Rymer, vol. xv. is a grant by Queen Elizabeth to Thomas Cooper, clerk of Oxford, for the exclusive printing of his Latin Dictionary. In 1585 a printing press was established at the expense of the Earl of Leicester, chancellor of the university. Joseph Barnes was appointed printer to the university in 1585. History.

Cambridge. At CAMBRIDGE John Siberch printed in 1521, when Erasmus resided there, and probably executed some of his books. Thomas Thomas, M. A. was the first printer to the university in 1584.

St Alban's. At ST ALBAN'S printing was very early practised, certainly in the year 1480. It would appear that the printer was a schoolmaster. It has been asserted, but without shadow of argument, that printing was introduced here many years before Caxton.

Early Scottish printers. Printing was not introduced into Scotland till thirty years after Caxton had set up his press at Westminster. Under the patronage of James IV., who was a zealous encourager of learning and the useful arts, WALTER CHEPMAN and ANDRO MYLLAR established the first printing press at Edinburgh, as appears by a royal privilege granted to them in 1507.[1]

The only publications known to have issued from the press of Myllar and Chepman are a collection of pamphlets, chiefly metrical romances and ballads, in 1508, of which an imperfect copy is preserved in the Advocates' Library;[2] and the Scottish Service Book, including the Legends of the Scottish Saints, commonly called the Breviary of Aberdeen, in 1509.[3]

It is difficult to account for the discontinuance of printing in Scotland for about twenty years after this time: probably the disastrous events at the close of the reign of James IV. may have contributed to render it an unprofitable trade; but in its revival by DAVIDSON there was no deterioration, either in the magnitude and importance of the works attempted, or in the mode in which the mechanical part was executed. It was probably about the year 1536 that he printed, in a black-letter folio, "The History and Croniklis of Scotland, compilit and newly correckit be the Reuerend and Noble Clerke Maister Hector Boece. Translatit laitly be Maister Johne Bellenden. Imprentit in Edinburgh be Thomas Davidson, dwelling fornent the Frere Wynd;" and in 1540 he printed the whole works of Sir David Lindsay.

Davidson was succeeded by Lekprevik, Vautrollier, and others; but none were distinguished as printers till the time of Ruddiman.

A mere catalogue of printers would afford little amusement, and less instruction; especially since the productions of the English press, save in the works of the printers above named, not only exhibited no advance, but even much deterioration, in most requisites of good printing. Indeed, to so low a point had the art fallen, and so little spirit was exhibited by English typographers, that the regeneration was left to an alien, whose perception of the inferiority and capacity of improvement at once raised the art to the level of the finest productions of Bodoni and Barbou.

Baskerville, Bulmer, &c. This was JOHN BASKERVILLE, a japanner of Birmingham, who, having realized a considerable fortune, turned his attention to cutting punches for type, and succeeded in producing a series of founts of remarkable beauty, so excellently proportioned, and standing so well, that the best o'

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[1] "James, &c. To al and sindrj our officiaris liegis and subdittis quham it efferis, quhais knawlage thir our lettres salcum, greting; Wit ye that forsamekill as our lovittis servitouris Walter Chepman and Andro Millar, burgessis of our burgh of Edinburgh, has at our instance and request, for our plesour, the honour and proffit of our Realme and liegis, takin on thame to furnis and bring hame ane prent, with all stuff belangand tharto, and expert men to use the samyne, for imprenting within our Realme of the bukis of our Lawis, actis of parliament, croniclis, mess bukis, and portuus efter the use of our Realme, with addicions and legendis of Scottis sanctis, now gaderit to be ekit tharto, and al utheris bukis that salbe sene necessar, and to sel the sammyn for competent pricis, be our avis and discrecioun thair labouris and expens being considerit," &c.

"Geven under our prive Sel at Edinburgh the xv day of September, and of our Regne the xx^{ti} yer."

[2] These pamphlets were reprinted in a handsome quarto volume, edited by Mr David Laing. The preface contains much accurate information regarding early printing in Scotland.

[3] Of this Service Book, which forms two volumes octavo, handsomely printed with red and black letter, in the years 1509 and 1510, a beautiful copy is preserved in the University Library of Edinburgh. As the name and device of Walter Chepman occur in the work, without any mention being made of his partner, we are led to the conclusion that Andro Myllar, if then alive, had relinquished his share in the concern.

History.

modern type-founders (and this seems the Augustan age of type-founding) have done no more than vary the proportions and refine the more delicate lines and strokes. Added to this, his press-work is of most excellent quality; his paper the choicest that could be procured; and his ink has a richness of tone, the mode of producing which has died with him. The works of Baskerville are amongst the choicest that can adorn a library. He died in 1775. His types and punches were purchased to print the splendid edition of Voltaire's works at Paris. He was worthily succeeded by BULMER, whose magnificent Shakspeare and MILTON are amongst the most superb books ever issued from the press, and, with Macklin's Bible and Ritchie's, Bensly's Hume, and other works, may be fearlessly produced to win for this country the palm of fine printing; whilst in Scotland THOMAS RUDDIMAN, and the two FOULIS, may challenge the prize of classical typography from Aldus and the Stephani. Indeed the larger Greek types of the Foulis are without parallel for grandeur; their press-work is beautiful, and their correctness beyond all praise.

Modern printers, with all their faults, are not degenerate successors of these worthies. The works from present offices that make pretensions to fine printing need not be ashamed of comparison with these *chef-d'œuvres;* whilst, from the vast improvements in the mechanism of the art in all its branches, paper, presses, ink, type, and other adjuncts, the average of the printing of the present day is infinitely superior to that of the last century. But in what relates to practical skill, correctness, taste, and diligence, we cannot hope to excel, though we may perhaps equal, these departed masters.

PRACTICAL PRINTING.

See Plate CCCCXV.

The first operation when the new fount[1] has entered the doors of the printing-office, is to *lay* it in the *cases*. These are always in pairs, the *upper case* being divided into equal spaces or *boxes;* the part on the left of the broader division being appropriated to CAPITAL letters, figures, accented letters, particular *sorts*, &c.; that on the right to SMALL CAPITALS and miscellaneous characters. The letters and figures are arranged in alphabetical and numerical order, from left to right. The *lower case* is divided into unequal portions, according to the average occurrence of the particular letters; for the compositor (the workman whose duty it is to lay the fount, and afterwards to place together or *compose* the separate types into words) never looks at the face of the letter he picks up, but unhesitatingly plunges his fingers into any box, being sure that the letter he picks out thence is the one to which that box is appropriated, and consequently the one he requires. As there is no external mark or guide attached to the different boxes to denote the letters they contain, a stranger is not a little surprised and mystified at the eccentric movements of the workman's hand. Accordingly, it will be observed, upon looking to the engraving, that the letter e has a box one half larger than any other, c, d, m, n, h, u, t, i, s, o, a, r, twice the size of b, l, v, k, f, g, y, p, or w, and four times the size of z, x, j, q, or the [] crotchets, full points, &c. These boxes are not arranged in alphabetical or any other order, but as experience has shown how the case may be most conveniently divided into the requisite proportions. There are also other pairs of cases similarly arranged for the *italic* letters. The fount is therefore *laid* or distributed in these boxes, when the following are found to be some of the proportions of the letters in a fount of pica of 800 lbs. weight:

Capitals, of each from 400 to 600,
Small capitals, from 150 to 300,

a	8,500,	b	1,600,	j	400,	z	200,
e	12,000,	c	3,000,	k	800,	&	200,
i	8,000,	d	4,000,	m	3,000,	,	4,500,
o	8,000,	f	2,500,	n	8,000,	.	2,000,
u	3,400,	h	6,400,	q	500,	&	200,

the whole fount comprehending the number of 150,000 letters, spaces, and figures.

Practical Printing.

Case.

The compositor having placed his copy upon a little-used part of the upper case, and having received the necessary directions, takes up an instrument called a *composing-stick* (which, as well as the way of holding it and its use, will be better understood by reference to the drawing than by description, see Plate CCCCXV.), and sliding that inner moveable portion fastened by a screw, wider or closer according to the desired width of the page, cuts to the exact size a piece of brass rule, called the *setting-rule*, which enables the letters to slip down without any obstruction from the screw-holes of the stick, or the nicks by which one fount is distinguished from another. He then reads the first few words of his copy, takes first a capital letter from the upper case, the succeeding letters from the lower case, and at the conclusion of the word a *space*, which is merely the shank of a letter without any face, and not so high as a letter by about one-fourth part. This therefore separates each word by a space, which cannot appear upon the paper, because the ink cannot be distributed upon it except by mismanagement, in which case it is a fearful blotch upon a fair page, and must have been observed by most readers. He then proceeds with his next word, which will probably consist of lower-case letters only, and so proceeds until he has arrived at the end of his line. It is most likely, however, that the words he has occasion to compose, with the necessary spaces, will not fill up the exact width of the line, and that there will be sometimes too much, sometimes too little, room for getting in the next or part of the next word. In this case he has to consider whether it will be better to crowd the line and get in the next syllable, or make the line more open and take it over to the next line; his care being that his matter, when composed, shall not look too white or too dark. Having decided, he takes out the spaces he has inserted, and puts in their stead others of greater or less width, as the case may require, in such a manner that on the face of the line being touched it shall not feel loose, or that it shall not require any particular pressure to force down the last letter into its proper place. This being accomplished in an artist-like manner, he takes out his setting-rule, and places it in front of his line, and with a gentle pressure of the thumb forces both back into the composing-stick; he then proceeds in a similar manner with other lines, until his stick is very nearly full, when, placing it upon the *frame* on which the cases are, his setting-rule being in front, he lifts his lines out of the stick in order to place them upon a proper instrument, called a *galley*. If, however, the matter is to be *leaded*, that is, if the lines of types are to be more apart than usual, the process is a little different. The compositor then has before him a quantity of pieces of metal called *leads*, of the exact width of the page, only one fourth, one sixth, or one eighth as wide as the type, and not higher than spaces. After composing a line, before moving his setting-rule, he takes one or more of these and places it before the line, then places the setting-rule, and so proceeds. Having thus gone on until a considerable quantity of matter is composed, the compositor next proceeds to make it up into pages, and then into sheets. First, taking by portions as many lines of his matter as are to be contained in a page, he adds thereto at the bottom a line of quadrats, which are the same as spaces, but much larger, being three, four, five, or six times as

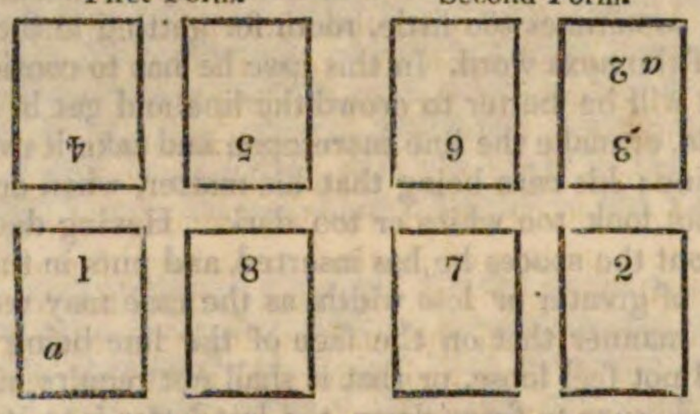
[1] A fount is any weight of type consisting of every letter, space, quadrat, &c. in certain proportions, instances of which are given below. See TYPE-FOUNDING.

Practical Printing. Case.

long as they are broad, and places at the top the folio of the page and the *running head*, or line which indicates the title of the work or the subject of the page or chapter, and then adds such leads or other things as may be necessary, taking care that in the first page he places the *signature* (a letter of the alphabet, intended for a guide to the binder), because by keeping this always outside, and the second signature on the next leaf, he cannot fold the sheet wrong. He next ties it tightly round with page-cord, and places it upon a piece of coarse paper. Having made up as many pages as the sheet consists of, viz. four if folio, eight if 4to, sixteen if 8vo, he next lays them down upon the *imposing-stone* (a large slab of marble let into a frame) in the necessary order. This is, to a stranger, a very curious arrangement; they appear to him to be placed at random, without any design or fixed rule, and as they are necessarily laid down in two divisions, one for each side of the sheet, one is of consequence the very reverse of the other. He may very easily instruct himself, however; for if he take a sheet of paper, and fold it into any required size, marking the folios with a pencil, and then open it without cutting, he will find they fall in curious irregularity. The pages are laid down on the stone reverse of the arrangement they have on the paper; for it must be remembered that every type and every page is like a seal, the reverse of the impression it leaves; consequently, were the pages laid down as on a marked paper, viz. the first page on the right hand, it would, in type, be at the extreme left, and so on. The following schemes of the *laying down* and *imposition* of a sheet of 4to, 8vo, and 12mo, will give some idea of the apparent confusion of this process.

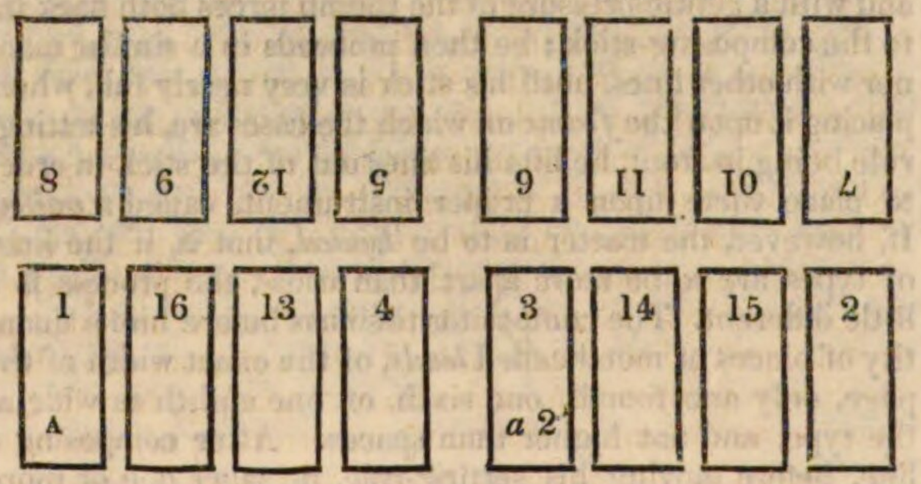
Imposition of a Sheet of 4to.

First Form. Second Form.



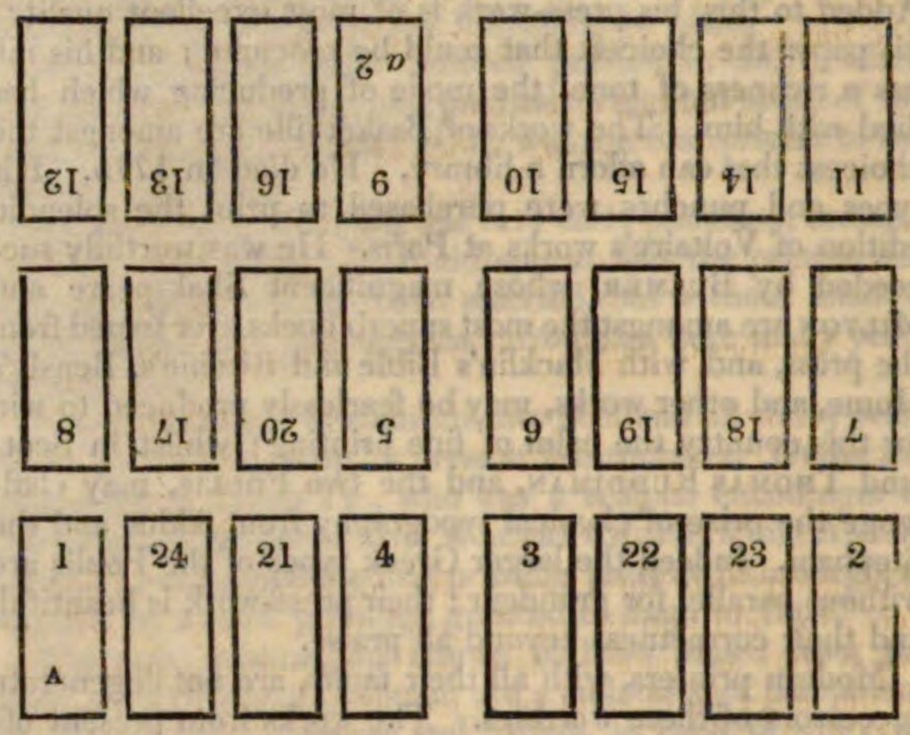
Imposition of a Sheet of 8vo.

First Form. Second Form.



Imposition of a Sheet of 12mo.

First Form. Second Form.



Practical Printing. Case.

The pages being properly disposed upon the imposing-stone, the compositor next takes a *chase* (a frame of iron divided by cross bars into compartments, the inner angles of which are made rectangular with much care) and places it over them, and then having ascertained the size of the paper to be used, adjusts pieces of wood or metal, called furniture, between them. Within the chase, but next to the pages, he now places other pieces of iron called *side* and *foot sticks*, which are rather wider at one end than the other, and between these and the chase small pieces of wood, which decrease in width in the same proportion as the side-stick, and which are called *quoins*. With a *shooting-stick* (which formidably-named weapon is merely a piece of hard wood, a foot in length, an inch and a half in width, and half an inch in thickness) and a mallet he forces the quoins towards the thicker ends of the side and foot sticks, which consequently act as gradual and most powerful wedges, forcing the separate pieces of type to become a compact and almost united body, so that, every side of the pages being again and again *locked up*, the whole mass, consisting of many thousand letters, may be lifted unbroken from the stone. This united mass is called a *form;* that one which contains the first page being called the *outer form*, the other the *inner*.

The compositor is paid by the number of thousands of letters he composes,[1] which is thus ascertained. The letter m, being on a shank which is perfectly square, is taken as the standard; he ascertains how many ms the page is in length, including the running head and the white line at the bottom; that is, in fact, how many lines of the particular type used there would be in a page of the given size, supposing it were all solid type; next, how many ms it is in width, that is, how many times the letter m would be repeated in a line of the given length were it to consist of nothing but ms. This latter sum is then doubled, because experience shows that the average width of the letters is one half of the depth, or one half of that of the letter m.

[1] In 1804, after a protracted litigation before the Court of Session, the journeymen compositors of Edinburgh succeeded in obtaining the sanction of the Court for an advance of one penny per thousand letters, or, upon an average, about one fourth on the prices of their work. The grounds upon which the Court rested this decision were, that the wages were much too low; that they had remained for forty years unaltered, whilst the price of the necessaries of life had very much increased; that it was proper to avoid a rise of wages which might lead to idleness, but equally necessary to place the workmen upon a respectable footing, so as to enable them to do their work properly, and also to encourage them in cultivating and acquiring that degree of literature by which the public must infallibly be benefited; and that the fair criterion was, to make the wages of Edinburgh bear the same proportion to those of London which they did in the year 1785, before the London prices were raised.

That a court of law, whose province it is, not to legislate, but to apply and enforce existing statutes, should have entertained a question regarding the price of labour, for the regulation of which there not only existed no law, but which had never been deemed a fit subject for legislative interference, appears to be a very singular incident in the history of judicial procedure. The prices thus fixed, however (namely, 4½d. per 1000 for book-work, with an additional halfpenny if nonpareil, and a penny if pearl, and 5½d. for law-papers and jobs), being regarded as not unreasonable, have ever since been adhered to by every respectable establishment in Edinburgh.

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The length of the page is then multiplied by the product of this doubled width, then by the number of pages in the sheet, and the result will give the average number of letters in the sheet. This will be much better understood by the following *casting up* of a sheet of 8vo in pica.

Number of ms long.....	47
... ms wide, 24 × 2.....	48
	376
	188
	2256
Number of pages in a sheet of 8vo.....	16
	13536
	2256
	36096

The compositor therefore is paid for composing 36,000 letters; for odd figures are dropped, unless they exceed 500, when they are paid for as if they completed another 1000. If the sheet be of solid type, and of ordinary size, the price paid in London is sixpence per 1000 letters; if the small type called minion, sixpence farthing; if nonpareil, sevenpence; if pearl, eightpence. If, however, the type be leaded, the price is a farthing per 1000 less; and if the work be composed from print copy, the price is three farthings per 1000 less than it would be paid if the copy were manuscript. Works in foreign languages are paid one halfpenny per 1000 more in the type of ordinary size, three farthings per 1000 more in the smaller. Greek with leads and without accents is eightpence halfpenny per 1000; without leads or accents, eightpence three farthings; with accents, tenpence farthing. Hebrew, Arabic, Syriac, &c. are paid double. The compositor, it appears, must therefore pick up 72,000 letters before he can receive an ordinary week's wages, must moreover correct all the blunders mischance or carelessness may have occasioned; and must make up his matter into pages and impose them, with great expenditure of time in many other particulars; but, as is hereafter described, he must have previously placed every one of these 72,000 into the appropriate boxes whence he has withdrawn them in composition. Now it is usually reckoned that this latter operation, called *distributing*, occupies one fourth of a compositor's time, and the other operations another fourth; he has therefore only one half of his time for composition; consequently he must pick up letters at the rate of 144,000 per week, 24,000 per day, or 2000 per hour. His hand has in picking up each letter to traverse a considerable space, say six inches, and back again, to his composing-stick. His rapidity of motion is therefore wonderful, and the exertion is so long continued, that the business, although apparently a light one, is in fact extremely laborious. The number of thousands of letters in a sheet necessarily varies with the size of the type, width and length of the page, and the number of the pages. The casting up above given is a solid pica sheet of demy octavo, of moderate page; a similar sheet of brevier would contain 81,000 letters, and the cost of composing it would be L.2. 0s. 6d. Single tables, forming one uninterrupted mass of type, will sometimes contain 250,000 letters; and the labour of the compositor being very great in getting up tables, he is paid double. Consequently the cost of composing such a table in pearl or diamond (see the 13th of Bell's Chronological Tables, 4th edit.) would be not less than L.16. 13s. 6d., without extra charges. Yet this infinity of types, by the power of the wedge-formed side-sticks and quoins, is formed into so solid a mass as to be moved without much danger of disruption.

The sheet being now imposed, an impression is taken, called a proof, which is carried down to the reader, who, having folded the proof in the necessary manner, first looks over the signatures, next ascertains whether the sheet commences with the right signature and folio, and then looks to the following folios. He now looks over the running heads, inspects the proof to see that it has been imposed in the proper furniture, that the chapters are numbered rightly, and that the other directions have been correctly attended to, marking whatever he finds wrong. Having carefully done this, he places the proof before him, with the copy at his left hand, and proceeds to read the proof over with the greatest minuteness, referring incessantly to the copy that no word may escape him, correcting the capitals or italics, or any other peculiarities, noting continually whether every portion of the composition has been executed in a workman-like manner; and having fully satisfied himself upon all technical points, he calls his reading-boy, who, taking the copy, reads in a clear voice, but with great rapidity and the least possible attention to sound, sense, pauses, or cadences, the precise words placed before him, inserting, without pause or embarrassment, from the most crabbed or intricate copy, every interlineation, note, or side-note. The gabble of these boys in a reading-room, where there are three or four reading, is most amusing, a stranger hearing the utmost confusion of tongues, strange unconnected sentences, and most monotonous tones; the readers plodding at their several tasks with the most iron composure, not in the least disturbed by the Babel around them. They follow carefully every word, marking every error, or pausing to assist in deciphering every unknown or foreign word. This first reading is strictly confined to making the proof an exact copy of the manuscript, and ascertaining the competency of the compositor, consequently first readers are generally intelligent and well-educated compositors, whose practical knowledge enables them to detect the most trivial technical deficiencies. Having thus a second time perused the proof, and carefully marked upon the copy the commencement, signature, and folio of the succeeding sheet, he sends it by his reading-boy to the composing-room to be corrected by the workmen who have taken share in the composition. These immediately divide the proof amongst them, and each, taking that portion of it which contains the matter he had composed, and going to his cases, gathers the letters marked as corrections in the margin, together with a quantity of spaces of all sizes, and returns to the forms, which in the meanwhile one of them has *laid up* on the imposing-stones and unlocked. He then with a blunt bodkin lifts up each line in which a correction is required, draws out the wrong letter and inserts the right one, adjusting the spaces in such a way as to compensate for the increased or diminished size of the letter substituted, overrunning carefully several lines should any word have been added or struck out, so that the spacing may be uniform, and the corrected matter exhibit no proof whatever of any alteration having been necessary. This is an operation requiring much practice and skill; and here is shown the value of attention in the preliminary operations. Should the types have been carelessly laid or improperly distributed, should the workman have been careless in composition, capitalling, or spacing, he will consume as much time in amending his errors as in composing his matter, to the great detriment of his work, the injury and inconvenience of his employer and his companions, and great delay in every part of the printing-office. Thus every compositor having taken his share, another proof is pulled, which, with the original proof, is taken to the same first reader, who compares the one with the other, and ascertains that his marks have been carefully attended to, in default of which, he again sends it up to be corrected; but should he find his revision satisfactory, he sends the second proof with the copy to the second reader, by whom it undergoes the same careful inspection; but this time, most technical objections being rectified, the reader observes whe-

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ther the author's language be good and intelligible; if not, he makes such queries on the margin as his experience may suggest; and having again followed his reading-boy, he sends it up to the compositor, where it again undergoes correction, and a proof being very carefully pulled, it is sent down to the same reader, who revises his marks and transfers the queries. The proof is then sent, generally with the copy, to the author for his perusal, and he having made such alterations as he thinks necessary, sends it back to the printing-office for correction. With the proper attention to these marks the printer's responsibility as to correctness ceases, and the sheet is now ready for press.

It need scarcely be remarked, that "correctness of the press" is a very material feature in every work, and more especially in those of a scientific nature. When the attention and the mind are devoted to the train of some close argument, or passage of surpassing beauty, it is surprising how easily an error of the press, even although it may not injure the sense, and may be as evident "as the sun at noon," will destroy the charm, and break the "thread of the discourse;" and even in works of ordinary reading they are exceedingly offensive. Many curious anecdotes are related of the methods which the earlier printers adopted to attain correctness. It was the glory of the early literati to take charge of the accuracy of new works; and, in return, the value and sale of each edition varied with the skill and reputation of the corrector. Of these Erasmus is an illustrious proof. Many of the first printers were led to the practice of the art by their love of learning, and their anxiety to promote it by the production of classic authors. Hence several are better known in the world of learning than in the circle of bibliographers; as the editors and correctors of valuable works, than as the careful or beautiful printers of them. Aldus, it is true, has so admirably succeeded in both characters, that he has fully established his double fame; but whether he most valued himself upon his learning or his skill may be doubted. It would appear from his letters that he considered it as his chiefest duty to correct every sheet that passed through his press. In all his bustle in preparing every material in use in his art, in all his occupations public and private, this important duty was never neglected. He tells us, "that he has hardly time to inspect, much less to correct, the sheets which are executed in his office; that his days and his nights are devoted to the preparation of fit materials; and that he can scarcely take food or strengthen his stomach, owing to the multiplicity and pressure of business; meanwhile," adds he, "with both hands occupied, and surrounded by pressmen who are clamorous for work, there is scarcely time even to blow one's nose;" nor did his son or grandson depart from his ways, but did themselves insure the correctness of their works, even when the latter had risen to wealth and eminence, and enjoyed the laborious dignity of a professor's chair. The beautiful Greek works of the Stephani are especially valued for their correctness. Stephens corrected his own press with intense labour and minuteness, and is reported to have adopted a singular plan for obtaining perfect similarity to the copy, by employing females who had not the slightest knowledge of the Greek characters or language to compare every letter of the proof with the manuscript; a labour so intense as to be almost incredible. He is moreover said to have hung up proofs on the doors of his printing-office, and to have amply rewarded any who could detect inaccuracies therein. Coverdale, it will be recollected, corrected the first English Bible and Testament, and received a bishopric as his reward.

The experience of every printer will furnish a host of laughable errors; and indeed these defects have been deemed of such importance as to deserve preservation. (D'Israeli's *Curiosities of Literature*.) The omission of the word *not* from the seventh commandment, in an edition of the Bible, printed by the Stationers' Company, is well known; and the company richly deserved the severe fine they incurred for spreading the immoral command, "Thou shalt commit adultery." The Bible so misprinted has received the name of the "Adultery Bible;" and a copy is preserved in the British Museum, the edition having been carefully suppressed. There is another Bible known as the "Vinegar Bible," from a misprint in the 20th chapter of St Luke, where "Parable of the Vinegar" is printed for "Parable of the Vineyard;" this proceeded from the Clarendon press. In the reign of Charles I. a very curious traffic in Bibles, &c. arose; they were printed by any one who chose, and imported in vast numbers from abroad. It will readily be imagined that these were made for *sale*, not for *use*, and that they abounded with egregious errors; but, what is worse than this, they were full of mistranslations and interpolations, and the omissions were fearful. All these were done as much by design as by accident, the Romanists and sectaries taking the opportunity of advancing their own tenets by interpolating and altering texts to suit their views. These monstrous anomalies produced, however, some good; they occasioned the necessity of the authorized version now in use, and printed under such authority as insures perfect fidelity, whilst there is sufficient competition to make it impossible that the Word of God can ever become a sealed book to the humblest and poorest Christian. Some of the blunders in these editions are sufficiently absurd to overcome the repugnance which must naturally be felt at such license. Thus, in Luke xxi. 28, *condemnation* has been misprinted for *redemption*. In Field's Bible of 1653, called the Pearl Bible, Rom. vi. 13, we find "Neither yield ye your members as instruments of *righteousness* unto sin," for *unrighteousness;* and 1 Cor. vi. 9, "Know ye not that the unrighteous *shall inherit* the kingdom of God?" for *shall not inherit*. It is said that these corruptions are in great measure owing to Field's cupidity, and that he received a bribe of L.1500 from the Independents to alter the text in Acts vi. 3, to sanction the right of the people to appoint their own pastors, "Wherefore, brethren, look ye out among you seven men of honest report, full of the Holy Ghost and wisdom, whom *ye* may appoint over this business," instead of *we*. This Bible is notorious, and, strange to say, valued, for its gross incorrectness. It is asserted that no less than six thousand errors of greater or less magnitude have been noted in it. But the most extraordinary example of carelessness is presented by the Vulgate the printing of which was sedulously superintended by no less an authority than Sextus V., a curious example of the infallibility of the pope. To the astonishment of the world, it swarmed with errors; and a whimsical attempt was made to remedy the defects, by pasting printed slips of paper over the erroneous passages. As this, however, was exceedingly laughable, the papal authority was exerted to the utmost to call in the edition, and with such effect, that it soon became very scarce, and a copy of it has produced the disproportionate sum of sixty guineas. To add to the absurdity, the volume contains a bull from the pope anathematising and excommunicating all printers who, in reprinting it, should make any alteration in the text. The monkish editor of *The Anatomy of the Mass*, printed in 1561, a work consisting of 172 pages of text and fifteen pages of errata, very amusingly accounts for these mistakes by attributing them to the artifice of Satan, who caused the printers to commit such numerous blunders; but he does not inform us whether it was really the archangel fallen, or only his minor satellite, the printer's devil. The editor of an Ethiopic version of St Paul's Epistles innocently confesses, in palliation of his errors, "that they who printed the work could not read, and we could not print: they helped us and we helped them, as the blind helps the blind."

The sheet being printed off in the way hereafter to be described, and the forms returned by the pressmen to the com-

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posing-room, and very carefully washed with lye, and rinsed with water, the compositor lays up the forms on a letter-board, and there unlocks them. Each compositor employed on the work then takes a share of the letter, and, wetting the face of it plentifully with a sponge, which causes the types to adhere sufficiently to prevent accidents, yet not so much as to retard the workman, takes up a portion on his setting-rule, with the nick upwards, and the face turned towards him; he then takes between his fingers and thumb a few letters, gives a rapid glance at the face to see what letters they are, and then passing his hand rapidly over the cases, drops each into its appropriate box. In this operation the greatest attention is necessary, for it must be remembered, that every letter dropped into a wrong box in distributing is sure to cause an error in composing; for the workman, as before stated, never looks at the letter he takes up, relying upon the correctness of the distribution. Compositors, therefore, should be especially careful, when learning their business, not to sacrifice certainty to swiftness; for in this instance most especially is it found that too much haste is little speed. If the rapidity of motion in composition strikes the stranger with wonder, what must that of distribution occasion? Most compositors distribute four times as rapidly as they compose; if, therefore, he pick up two thousand letters in an hour, he would distribute eight or ten thousand, or about three per second. His letter being properly distributed, he again proceeds to compose in the manner before described, until the work is finished. The number of times the letter is returned must depend upon the size of the fount. A thousand pounds weight of types would get up five or six sheets, and, therefore, in a fair octavo volume, the letter would be returned five or six times.

Press.

The Press is the machine whereby impressions are obtained of the type, when set up by the compositor as above described. On the skill and care of the pressmen depend the beauty of the work. If the press-work be not good, all the labour of the compositor is thrown away; his work makes no respectable appearance, and the master gets no credit.

It has already been mentioned, that very little alteration had been made in the printing press from the time of the first printers to that of Blaew of Amsterdam, about 1620. Blaew's improvements, although of immense advantage, only consisted in alterations in the details, and not in the principle. Blaew's presses have in their turn been superseded by those of Lord Stanhope; and very few are in existence, in England at least, save in old offices, where they are used as proof-presses, or kept merely as curiosities. A description of a bygone piece of mechanism would be of little utility; to show, however, Lord Stanhope's ingenious invention, it is necessary to make the reader understand the original construction. As a great part of the old press is retained in the new, one description will serve for both; premising that the old presses, as well as those first fitted with the Stanhope power, were of wood, but that very soon the latter were constructed of iron, and that, in consequence, the general appearance of the press was much altered. A press then consisted of two upright pieces of immense strength, which rose perpendicularly from the floor to the height of six feet and a half, and were connected with cross pieces. From about the middle of each of these a slide, called a rib, projected at right angles, and perfectly parallel to each other; a spindle with a powerful screw, kept in its place by these cross pieces, worked in a box called a hose, by means of a bar or lever inserted in it; the toe of the spindle worked in a sort of cup fixed upon a large solid block of mahogany, having the face planed perfectly smooth, and called the platten. It will be evident, that when the bar is pulled down, the spindle will descend in proportion to the worm of its screw, and force down the platten to precisely the same degree, and with great power. A table was made to run in and out upon the above-mentioned ribs; upon this was the form of type; when run in, it was exactly under the platten, and having been previously inked, and the paper laid on it, the bar was pulled over, the spindle, platten, &c. descended, and the consequence was a very powerful pressure of the paper between the platten and the type, causing the latter to give a perfect fac-simile of its surface upon the paper. Lord Stanhope's invention consists in an improved application of the power to the spindle and screw, whereby the power is multiplied many times. This will be best understood by describing an iron press of the modern construction. Upon reference to the engraving, this will be found to consist of a very heavy mass of iron, called the staple *aa*, the outline of which somewhat resembles that of a vase. It is united at the top and bottom, but the neck and body are open. The upper part is called the *nut b*, and answers the purpose of the head in the old press, as it is in fact a box with a female screw, in which the screw of the spindle *c* works; the lower portion of the open part described as the neck is occupied with a piston and cup *d*, *d*, in and on which the toe of the spindle works. On the nearer side of the staple is a vertical pillar or *arbor e*, the lower end of which is inserted into the staple at the top of the shoulder; the upper end passes through a top-plate *f*, which being screwed on by the upper part of the staple, holds it firmly. The extreme upper end of the arbor being hexagonal, receives a head *g*, which is in fact a lever of some inches length; this head is connected by a *coupling bar h*, to a similar lever or head *i*, into which the upper end of the spindle is inserted.

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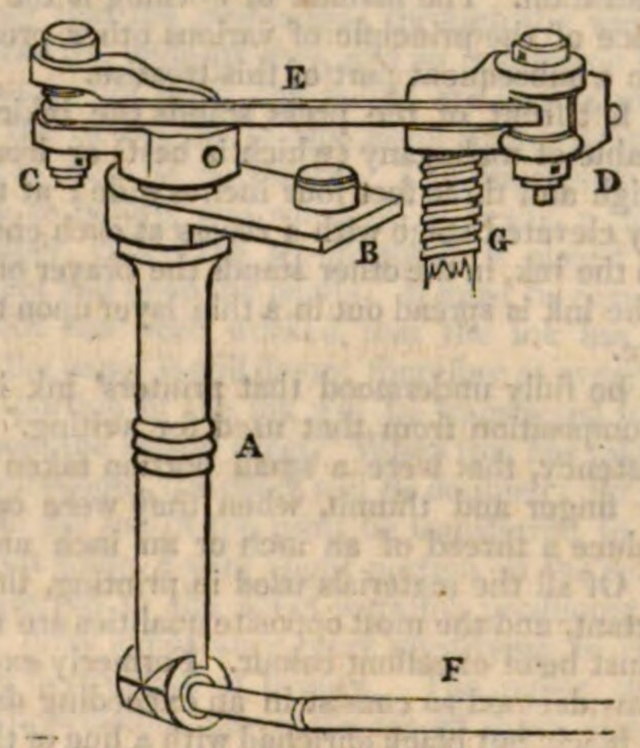

A, the arbor. B, the top-plate. C, the arbor-head. D, the spindle-head. E, the coupling-bar F, the bar or lever. G, the spindle and screw.

The bar or lever *k*, by which the power is applied by the workman, is inserted into the arbor, and not into the spindle, by which ingenious contrivance, 1st, the lever is in length the whole width of the press, instead of half, and is, moreover, in a much better situation for the application of the pressman's strength; 2d, there is the additional lever of the arbor-head; 3d, the additional lever of the spindle-head; and, lastly, the screw itself may be so enlarged in diameter as to have immense increased power. The platten is screwed on to the under surface of the piston; the table *m* has slides underneath, which move *in* the ribs *n*, *n*, instead of *upon* them, and is run in and out by means of girths affixed to each end, and passing round a drum or wheel *o*. As the platten is of considerable weight, the workman would have to waste much strength in raising the platten from the form after the impression has been given, were not a balance-weight *p* suspended upon a lever and hook at the back of the press, which counterbalances the weight of the platten, raises it from the form, and brings the bar-handle back again, ready for another pull. These are the principal parts of the ma-

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chinery whereby the impression is given, and are sufficient for the general reader, with the aid of the engraving in Plate CCCCXV. For the printer there are yet other appliances. At the right-hand end of the table is an iron frame *q*, moving freely upon pivots, so as to fall upon the table, or rise until stopped by what is called the gallows *r*; this is covered with parchment very tightly stretched, and is then called the tympan; upon the tympan blankets are placed, which are covered by an inner tympan, and fastened by hooks; the whole forming a solid yet elastic and yielding surface, admirably fitted for impressing the paper upon the type (for this is its use), inasmuch as the surface of the parchment is soft and without grain, and readily receives the impression of the type, while the blankets give freely to every projection, without retaining any indentation. To protect those portions of the paper which are not destined to be coloured from ink or soil, there is at the upper end of the tympan another iron frame, of much lighter make, and also moving upon pivots, so as to fall upon the face of the tympan. This is covered with a sheet of coarse paper, and the exact size and form of the pages are carefully cut out therefrom, the parts left being an excellent protection of the paper under them. This is called a frisket.

Such is the ordinary Stanhope press. Since this was introduced many excellent presses have been invented, and very extensively introduced; but this is so simple, so easily kept in order, and so powerful, that it has never been excelled; and being very intelligible, has been chosen for the illustration. The manner of working is the same in all. A notice of the principle of various other presses will be found in a subsequent part of this treatise.

On the left front of the press stands the inking table. This is a table of mahogany (which is best) or iron, about four feet high and three feet four inches wide; at the back is a slightly elevated stage with a recess at each end, in one of which is the ink, in the other stands the brayer or muller, by which the ink is spread out in a thin layer upon the front of the stage.

Printers' ink.

It must be fully understood that printers' ink is a very different composition from that used for writing. It is of such consistency, that were a small portion taken up between the finger and thumb, when they were opened it would produce a thread of an inch or an inch and a half in length. Of all the materials used in printing, this is the most important, and the most opposite qualities are required in it. It must be of excellent colour. Formerly excellence of colour was deemed to consist in an exceeding dark hue, not exactly black, but black enriched with a hue of the darkest blue or purple. This gave indescribable effect to the works for which it was used, a richness, a gorgeousness, which it is impossible to describe; but the works of Baskerville and Bulmer, especially the Milton of the latter, afford the best specimens. *Now* we hold perfection to consist in the intensest black, and all the resources of chemistry and the arts have been sought to attain this end. It must stand for ever; but here we have miserably failed. Compare the productions of the old printers with those of twenty years back. What a difference! The works of the Aldi and Elzevirs, of Plantinus, Caxton, Pynson, and Grafton, preserve their colour as intense as the day they were printed; there is no yellowness or brownness, no foxiness, whilst the books of those of 1810-20 are wretchedly discoloured. Where fine printing, however, has been required *and paid for*, the modern ink is no whit inferior to the ancient. Witness the beforementioned works of Bulmer, Macklin, Ritchie, Bowyer, Baskerville, and others; but certain it is that the ink in general use twenty years ago was of very inferior quality. It must be perfectly mixed, and ground until it is absolutely impalpable, otherwise it will speedily clog the types and inking apparatus; it must adhere to the paper, and not to the type, or it will tear off the face of the former, and clog up the latter; it must be sufficiently thick; it must keep perfectly undried when in large masses, and dry very quickly when it is distributed in thin surface. No printers of the present day make their own ink, although some add ingredients which they believe to improve the colour or quality. It is an especial business, and, by the aid of machinery, capital, and exclusive attention to the manufacture, the ink now supplied is admirable in the qualities of thorough mixing and grinding, drying, blackness, &c.; but whether it will stand the test of time, time alone can show. It is an expensive article, the commonest book-ink being one shilling and sixpence per pound, whilst the usual qualities are two shillings and sixpence, three shillings, and four shillings per pound; those used for superior work are five shillings and six shillings, and those for cuts as high as ten shillings, though it is questionable whether, at the latter price, the consumer is not paying for a mere name.

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Every manufacturer has, of course, his own secrets, both of ingredient and process. The universal ingredient is the finest possible lamp-black; the great secret probably consists in the manner in which, and the material from which, this is made. There are vast buildings appropriated to the sole purpose of burning oil, naphtha, spirits, coal-gas, &c. to produce this black, which is collected from the sides, ceilings, &c. of the buildings. It is brought from Germany and many other countries; and no expense is spared to get the most superior quality. The next most important article is nut or linseed oil boiled and burnt into a varnish; then oil of turpentine, &c. The following receipts have been given. The first is the method used by Baskerville and Bulmer, and nothing can be better than the results.

1. Fine old linseed oil boiled to a thick varnish, and cooled in small quantities, three gallons; a small quantity of black or amber rosin dissolved therein; the mixture then stands for some months, that all impurities may be deposited; after which it is mixed with the finest lamp-black, and carefully ground for use.

2. One hundred pounds of nut or linseed oil are reduced by boiling and burning one tenth or one eighth of its bulk, and to the thickness of a syrup; two pounds of coarse bread and several onions being thrown in to purify it from grease. Thirty or thirty-five pounds of turpentine are boiled apart, until, on cooling it on paper, it breaks clean, without pulverising. The former is poured nearly cold into the latter, and well mixed. The compound is then boiled again. Lamp-black is next thoroughly mixed with it, in quantity according to the ink required, and being well ground, the ink is then ready for use. Some add indigo, some Prussian blue, which considerably improves the colour; but these inks are so difficult to work, and so clog up the type, that the *improvement* is better let alone. The turpentine is added to give greater varnish, and improve the drying quality; but if the oil be old and fine, the quantity required is proportionally less.

3. Mr Savage, an admirable artist, denies that any ink can be depended on, of the varnish of which oil is the basis; he therefore gives the following receipt:—Balsam capivi, 9 oz.; best lamp-black, 3 oz.; Prussian blue, $1\frac{1}{2}$ oz.; Indian red, $\frac{3}{4}$ oz.; turpentine soap dried, 3 oz. This ink is of beautiful colour, but appears to work foul. There can be no doubt, however, that the best and cheapest plan is always to purchase what is required of a proper ink-maker.

Press.

At the right front of the press stand the *bank* and *horse*. The bank is a deal table of some size; the horse is an inclined plane which stands upon the bank; upon it is laid the white paper prepared for working, which, when worked, is brought from the press to the bank. There are two pressmen to each press, one of whom attends to the inking only, to ascertain the excellence of which he turns, whenever he has a moment to spare, to the worked sheets upon the bank, glancing his eye rapidly over each to see that every part

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is of its proper colour, and that no picks, or other impressions, mar the work; the other attends only to the press, and gives the impression. These men are paid by every two hundred and fifty impressions, or by the *token*. Thus, if the number be five hundred, and the price fourpence-halfpenny per token, each man receives ninepence for the five hundred impressions of each form, and the cost therefore is,

First form, two men, two token, at 4½d.....1s. 6d.
Second form, do. do. do. .....1s. 6d.

3s. 0d.

The price necessarily varies with the size of the type and of the form; with the quality of the paper and of the ink; with the number, and the care required. Common work is fourpence-halfpenny, good sixpence, superior sevenpence, the very best eightpence, ninepence, or even twelvepence per token.

The pressmen, having received the forms after the final correction, lay the inner form, or that one which contains the second page, upon the table of the press, and secure it in the centre by quoins; one of them, in the meanwhile, pastes a stout sheet of paper upon the frisket frame, and then secures it upon the tympan. They then ink the form, and take an impression upon the frisket, and cut away all the printed part, which therefore leaves so much of it as is necessary to protect the paper from soil. The puller now carefully folds a sheet of the paper according to the crosses of the chase, and laying it upon the form, opens it carefully, by which the paper is made to lie evenly upon the form, with the same margin with which it is to be afterwards worked. Having wetted the tympan, the pressman closes it down upon the form, and takes an impression, when the paper will be found to adhere to the tympan, and thus become a guide whereby to lay all the subsequent sheets, and therefore much care should be taken to lay it properly. They now choose their points, which are thin iron arms, having a short point projecting from the end, and made to screw on to the tympan-frame, which must be done in such a manner as that the points may fall in grooves in the cross of the chase; because if they did not, they would be battered and broken upon it at the first pull.

The puller now brings his paper from the wetting-room; for before any good impression can be taken the paper must have been damped, by rapidly passing it, one fourth or one fifth of a quire at a time, through water, and then allowing it to soak for two or three days, until it is evenly and thoroughly damp; and, laying a ream upon the horse, he takes a sheet, and placing it carefully over the tympan-sheet, closes the frisket over it, shuts both tympan and frisket down upon the form, which in the meanwhile his companion has inked (a process that will be described below), runs the table in under the platten, pulls the handle of the bar or lever over by his full weight, until brought up by the stop, at which moment the platten descends and gives a powerful impression to the tympan, &c. upon the form, producing upon the paper a perfect fac-simile in reverse of the surface of the latter. The pressman now gradually releases his hold, the balance-weight raises the platten, the bar returns to its first position, the table is run out, the tympan and frisket are raised by the workman, and the frisket thrown up to the catch. The sheet is taken off the points, which the impression has caused to pierce through it, and carefully examined to ascertain that the impression is just and even, which is the great test of the workman's skill, and the excellence of the press. Invariably the first impression is defective; the parchment may have been thicker in some parts than in others, the blankets worn, or one of two founts of type may not have been of equal height, in which respect "the estimation of a hair" would be a monstrous fault, the thinnest possible tissue paper being quite sufficient for remedy. The pressman proceeds to overlay, that is, to paste upon his tympan-sheets portions of paper of the exact size of the defects, thicker or thinner as may be required; or if the defect be great, he places a part of a sheet of paper within his tympans. If there be any small portion of undue prominence, or that "comes off hard," he rubs away a portion of the tympan-sheet with wet fingers, or cuts it away altogether. Having, as he supposes, remedied all blemishes, he takes another impression, which he again examines with equal closeness, and carefully removes every remaining defect by the same method; having at length satisfied himself, and his master or overseer, the work is proceeded with, the inker taking even portions of ink well distributed, and covering the form equally, the puller taking a sheet, and laying it on the tympan as before. They thus proceed until the whole number of the white paper is worked off. The form is now lifted from the table, and carefully washed with a very strong lye. The outer form is then laid on and made ready.

This varies a little from the mode previously described. It has been stated that the points penetrate the paper at the first impression. These holes and points are the guides whereby perfect register is obtained; that is, whereby not only the pages, but the lines, are made to fall exactly upon the back of each other, a deficiency in which is a great fault in good book-work. The form, therefore, having been placed in precisely the same place as the previous one occupied, one of the sheets which have been printed on one side is taken and placed with the face inwards, in such manner that the points pass through the same holes, but of course the opposite way, and an impression is taken. If the pages do not back, the points are shifted until they do; or if the defect be in the form, such alterations are made in it as may be necessary. The impression is then brought up as before, and when all is ready, a thin sheet of white paper, called the *set-off* sheet, is placed over the tympan-sheet and upon the points. It must be remembered that one side has been worked, that the ink has not yet dried, that the paper is still damp; therefore at every impression some portion of the ink will be transferred to, or impressed upon, the set-off sheet. When this has taken place in many impressions, the effect will be doubled; for not only will some of the ink of the print be transferred to the set-off sheet, but some, a very slight portion, of the set-off will be re-transferred to the sheet working, producing a most unpleasing dirty appearance, very mystifying to the eyes, and utterly destructive of beauty. The puller, therefore, after a few impressions, moves the set-off sheet slightly, and when it has become very dirty, discards it, and replaces it with another. The pressman should be very attentive to this; and the master should not grudge ample supplies of set-off paper, for it is not destroyed, but is very useful afterwards in other departments as waste paper. The form is now lifted and carefully washed with lye, and the two are sent to the composing-room, where they are again carefully washed and rinsed, and are then ready for distribution. Two good pressmen are supposed to do about one token, or 250 impressions, per hour, of fair work. This, however, must depend entirely upon the quality of the work required; with small type, stiff ink, and many rules, the work is more slow, and paid for accordingly. The finest work is seldom paid for by the token, the pressmen being placed upon weekly wages, and allowed as much time as they require, the rapidity being at the discretion of the overseer. Frequently they are limited to a certain number per hour, often as few as fifty, the most careful inspection being given to every sheet by both pressmen, and continual attention by the press-overseer and other chief persons in the establishment. In such work the very best materials are employed. Instead of parchment, the tympans are covered with fine calico, and even silk; instead of blankets the finest broad cloth, picked blotting-paper for the thick overlays, the thinnest tissue-

Practical Printing. Press.

paper for the finer. It will readily be understood, that in all operations of the press-room, where everything depends upon the skill of the workmen, there are infinite minutiæ, which it would be tedious, if it were even possible, to enumerate. Seven years apprenticeship are not more than sufficient to educate a good pressman. It is the accumulated labour of a life to make a first-rate one; and, after all, excellence depends upon the native talent and ingenuity of the man himself.

The ink is distributed over the type either by balls or by rollers. The rollers are of modern use; the balls were, until a recent invention, sheep-skins with the hair taken off with lime, made into a ball with wool, gathered at all corners, and nailed upon a wooden handle. One of these was held in each hand; and a small portion of ink being taken, they were well beaten upon the inking-table, and then upon each other, until the ink was so evenly distributed over the whole surface, that if touched gently with the finger, the prominent lines of the skin would be perfectly blackened, whilst the channels would be left perfectly clean. The balls were then beaten over every part of the type, so that the whole surface should be evenly covered; an operation requiring much skill and practice. The skins were prepared and softened by the nastiest processes imaginable, which converted a press-room into a stinking cloaca. Thanks, however, to the observation and ingenuity of Mr Donkin and Mr E. Cooper, this has been entirely done away, and a press-room now almost regales the nose with a warm scent of ink and paper, anything but unpleasant. This invention has been of the greatest consequence to printing. The printing machine is popularly said to be the great engine of modern literature; and so it is; but without this, printing machines were mere old iron and brass. For many years the workmen in the potteries had used a composition of glue and treacle for applying colours to their ware. Mr Donkin observed that this composition possessed every requisite for the use of the printing-office, and he immediately proceeded to form balls of canvass, with a facing of composition. They answered admirably, proved beautifully soft, distributed beautifully, kept clean, and were easily washed and purified if soiled. Some opposition was offered by the workmen; but their advantages proved so great that they were readily adopted by the masters, and speedily drove away for ever the nasty skins. The next step, however, was more important still. Mr Donkin bethought him, that if he could cast rollers of composition, without seam and perfectly cylindrical, it could not fail to be of infinite utility to machine-printing. It remained, however, for Mr Cooper to suggest the substitution of them for balls at the common press. In this he succeeded; but it is astonishing how much difficulty there was in persuading the men to lay aside their old habits. They could not conceive that a straightforward rolling would answer the purpose of their laborious and careful beating. The rollers were nicknamed "rolling-pins," but they made their way, and are now in general use. They consist of a wooden cylinder, with a thick coating of composition cast perfectly true; through the middle of the cylinder passes an iron rod attached to a curved bar passing over the roller, upon which are two handles; and the roller revolves freely upon the rod. The pressman having brayed out a narrow line of ink upon the raised stage of the inking-table (or upon a distributing roller which runs the whole length of the table, and, being turned, presents a line of ink to the inking-roller), takes a portion of this upon the composition, and distributes it carefully upon the table until the entire face is evenly covered, and then rolls the form, taking care that the whole surface receives its due proportion. If he does this lightly and steadily there is no fear of the result; he cannot in rolling overlook any part; but it nevertheless requires some judgment. If there be any heavy titles or large type, he must roll that portion several times; if there be blank pages, he must take care that the roller does not sink, and so leave the pages in line with it slightly touched. The chiefest judgment, however, is displayed in choosing the exact quantity of ink required for the form. If the type be small, the quantity taken must be small; it must be very carefully distributed, and the form rolled many times; for if the quantity be too great the type will become clogged, and if too little, the colour will become faint. The pressman must from time to time examine the sheets as they are printed, turning up the corners of the sheets that he may see whether the colour corresponds to that of the side first worked, and detecting with quick eye every defect; and he must be particularly careful that for every sheet of the same work he take the very same quantity of ink, that the book when bound may present an even and beautiful colour, every bold line being perfectly covered, and yet every fine stroke clear and distinct. This can only be effected by careful distribution and repeated rolling, with exact judgment as to the quantity of colour to be taken.

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Warehouse.

The sheet having been thus worked off, the printed paper is taken away by the warehouseman, and hung by the boys upon poles stretched under the ceiling, by means of a peel, which is a handle with a broad end, upon which a quire or two is hung at a time, thence transferred to the poles, and distributed in portions of four or five sheets. Here they hang a day or two, until the ink and paper are perfectly dry. This should be a gradual process, for if by artificial heat the drying is hurried, a skin will be formed upon the surface of the ink, which will prevent that underneath from drying; the work will look very well until it is pressed or bound, when the skin breaks, the ink spreads, and the sharpness of the letter is entirely destroyed. When perfectly dry they are taken down and laid in heaps upon the gathering board, each signature separately; thus, first, a heap, say 1000, of B, then C, D, E, F, and, lastly, the title-sheet A. The boys then take one sheet from each heap; consequently, when they have got to the last signature, each boy has one complete copy of the work. These are laid upon one another in such a manner that each book is perfectly distinct. The warehouseman then takes a collator (a needle inserted in a handle) and goes over the whole with great rapidity, ascertaining that no sheet has been carelessly omitted, and that no two of the same sheet have been taken. The books are then folded down the middle, counted out in tens, thirteens, or twenty-fives, and tied up in fifties. The process of printing is thus complete, and the work is ready for the binder.

Pressing.

Works of finer description, indeed most works of the present day, are submitted to another process after they have been taken down from the poles, viz. hot or cold pressing, which very much improves their appearance. In cold pressing the sheets are placed one by one between glazed boards, or sheets of coarse material pressed until there is a perfect glaze upon both surfaces. The heaps are then placed in an hydraulic press, with cold iron plates at small distances, and the whole is subjected to considerable pressure for some hours; they are then taken out and the sheets extracted from the boards, when the indentations consequent upon the working will have been all pressed out, the roughnesses of the paper smoothed out, a slight gloss given to the ink, and the whole will present a very agreeable smoothness to the eye and the touch. Hot-pressing is used when the paper is very stout and the ink strong. The sole difference is, that the iron plates are heated until they can hardly be touched. The effect is much greater than that of cold pressing; the whole surface of the paper is perfectly glazed, and the ink absolutely shines; but the effect is not so agreeable to the eye; it is too glossy. As these processes also make the books lie perfectly flat, they render great beating by the binder unnecessary, doing away with the danger of such beating causing the ink to set off upon the opposite pages, which danger, should it from circumstances prove necessary to beat the book much, is considerably diminish-

Practical Printing. Warehouse.

ed, as the pressing sets the ink very effectually. The glazed boards must be often cleaned by rubbing with waste paper, or they will dirty the sheets placed between them. Every printing-office of credit should have an hydraulic press and boards; for it is incredible how much smartness pressing gives to the work, and how greatly the warehouse work is facilitated by the readiness with which the hydraulic is pumped up, and by its great power. A press of eight-inch ram will be found sufficient for most purposes; but where much hot and cold pressing are required, one of nine-inch ram will prove cheapest, because, from its immense power, a few hours are sufficient to give the requisite surface, and the press may therefore be filled twice a day.

Of casual variations in printing. Wood-cuts.

Wood-blocks are very often worked with the common type. The block, having been carefully reduced by the engraver to the exact height of the type, is placed in the composing-stick, and justified to the width of the page; it is then made up along with the other matter in its proper place. When laid upon the press for working, and an impression of the form has been taken, the pressman examines with great minuteness whether it stands well with the type; if not, the form is unlocked, and paper placed under it if it be too low, or under any corner that may be lower than the rest; if the block be too high it must be scraped or filed at the bottom. Anciently the artist in wood contented himself with producing his lights and shades by cutting his lines in greater or less degrees of fineness upon a plane, leaving to the printer the task of producing the required effects by a tedious process of overlaying; but since the introduction of machines, in which such method is impracticable, from the nature of the impression, and from the immense loss consequent upon the machine standings till whilst the cut is in preparation, several eminent engravers have turned their attention to the subject, and have succeeded in a method of so cutting away the block that it is put into the printer's hands in a great measure prepared. Notwithstanding this vast improvement, the pressman has much to do; he is to a certain extent an artist, and must have a good eye for perspective, and for the proper adjustment of tints. These effects he produces by careful and skilful overlaying. The cut may then be worked with the type without any other care than that of keeping it clear from clogging or picks. When done with, it must be very carefully cleaned with spirits of turpentine and a brush.

The working of wood-cuts by themselves as illustrations of works, differs from type-printing in no other respect than the superior materials and skill required. The wood-cut must be imposed in a chase, and locked up upon the table of the press, which is generally a smaller one than that used for ordinary printing, of most excellent construction, and in good order. The tympans are often of silk or cambric.

Composition balls and rollers

There are in London, and probably in the larger provincial cities, parties who make an especial business of the manufacture of composition balls and rollers, which they supply to printers upon payment of a rent. The skill and experience of these persons enable them, as must be the case in every instance where a manufacture engages exclusive attention, to supply a much better and cheaper article than could be manufactured by any individual whose engagements are varied; consequently there are not many printers, either in town or country, who do not avail themselves of these opportunities. The rent is paid for each roller required, and by the quarter; that is to say, if a printer employs six presses, and consequently six rollers, he pays for six rollers, the manufacturer engaging to supply him with as many changes as he may require from their getting out of order or being injured; in fact, to keep him supplied with six rollers in good condition. The rent for a common press-roller is the moderate sum of six shillings per quarter; they are sent into the country in boxes fitted for the purpose. There are, of course, situations in which it is not easy to obtain a regular supply of the necessary article, and in this case the printer may very easily make them for himself; but the expense of the utensils is so great as to exceed the usual rent for years. They consist of the following: For rollers, a hollow cylinder of brass, the bore of which must be most accurately turned and well polished; this mould consists of two semi-cylinders closely fitted and brought into contact by screws along the sides and collars at the end, and a head is made to fit into the lower end. The core, a wooden cylinder, upon which the composition is cast, is held in the centre of the bore by means of a star, through the radii of which the composition flows. For balls are required a concave mirror of about half an inch cavity, and a board of the same size, and of a quarter of an inch in convexity. A kettle for melting and mixing the composition is also required. This is made double like a glue-pot, fitting exceedingly close, and with a small orifice for the escape of the steam from the hot water between the two; and the inner vessel should have a large lip. The recipes for making the composition vary, and this appears to arise from the different circumstances under which it is made. The ingredients are but three, and these easily purchaseable, viz. fine glue, treacle, not that procured from the bakers, which is adulterated, but the best from the sugar-refiners, and a small quantity of carbonate of barytes, called in commerce Paris white. The first two are quite sufficient with a little skill. The following are good recipes.

Practical Printing. Rollers.

1. Two pounds of glue to one pound of treacle.
2. Two pounds of glue to three pounds of treacle.
3. One pound of glue to three pounds of treacle and a quarter of a pound of Paris white.

Soak the glue in water until it is soft; then place it in the inner vessel, and boil quickly, until the glue is thoroughly dissolved; add the treacle, mixing it well, and let it boil for an hour or more; then sift in the Paris white, but do not stir it violently, or the mixture will be full of air-bubbles, which are destructive to the roller or ball. Rub the mould slightly with a rag dipped in thin oil, taking care that no globules and streaks remain upon the surface. When the mixture is ready, pour it gently between the radii of the star, so that no air be detained within the cylinder until the mould be filled; allow it to set, and then take it from the mould, cutting off the superfluous portion with a string. When the roller has been hung up twenty-four hours it will be fit for use. In making balls, having oiled the mirror, pour the composition upon the centre, and having allowed it to spread itself, lay over it a piece of coarse canvass, place the board upon it, and lay weights upon it to press it down; it will consequently be found that the composition face of the ball will be slightly thicker in the centre than at the edges, which, besides being a convenience in the working, will allow it to be *knocked up* with much facility, which is done in the ordinary manner. These balls and rollers are very easily kept in order; if they are too soft, cold water will harden them; if too hard, warm water will soften them. When not in use they should be covered with refuse ink, and hung up in a room of even temperature, and carefully scraped with a palette-knife before use. They should not be cleaned with spirits of turpentine, as that will give them a hard surface. These rollers will be fit for use for a long while if attention be paid to them; and when spoiled, the composition may be repeatedly melted down, and, with an addition of new materials, will make as good rollers as before. When the proper apparatus is wanting, small balls for wood-cuts or single pages may be made upon an earthen palette, or even upon a smooth dinner-plate.

Stereotyping.

Stereotyping is a mode of making perfect fac-similes in type-metal of the face of pages composed of moveable types.

Practical Printing. Stereotyping.

Letter-press printing being a very expensive process, the price of books consequently high, and the heaviest expense consisting in the composition, the printers of the Continent very soon set up the entire of such small works as were in constant demand, and thus were enabled to sell them at little more than the cost of paper and press-work. Some works of very great extent, especially Bibles and prayer-books, were kept standing by the privileged printers. This, however, was exceedingly expensive, as the cost of type would be enormous; the forms would occupy vast store-rooms, and be liable to continual damage, both from the accidental dropping of letters, from batters, and other accidents to which they would be unavoidably liable. Some method, therefore, by which all or some of these disadvantages might be remedied, was sought after with great anxiety. About the beginning of the eighteenth century, Van der Mey, in Holland, sought to avoid this liability to accidents, by immersing the bottom of his pages in melted lead or solder, and thus rendering them solid masses: "c'est une réunion des caractères ordinaires par le pied, avec de la matière fondue, de l'épaisseur d'environ trois mains de papier à écrire;" therefore the mass together would be of somewhat less than the height of our type. It is not very easy to guess how they contrived to make the backs of these blocks of such evenness as to produce anything like a good impression; but Dibdin says that the book is very handsome. The same process was followed by a Jew of Amsterdam, in printing an English Bible; but he was utterly ruined by his speculation.

Some time before the year 1735, there is sufficient evidence that the French used casts of the calendars placed before church-books. These plates are thus described by Camus: "It (one of the plates) is formed of copper, and is three inches and a half long by two inches broad and one seventh of an inch thick. From the roughness of the casting, it has evidently been made in a mould formed of sand or clay." After the plate had been cast, the back of it had been dressed with a file, in order that it might bear equally upon a block of wood to which it had been attached.

Who really invented the art of stereotyping as at present practised (and, after all, he who finds out the efficient *modus operandi* is the inventor of the art, though he may not be of the principle), is, like the inventor of the parent art, a matter of some controversy, which has been carried on with more vigour than the subject merited. It seems however most probable, when all assertions are weighed, that William Ged, a goldsmith of Edinburgh, deserves the credit; thus exhibiting a singular coincidence with Fust. According to his statement, being in 1725 in company with a printer, they lamented the want of a good letter-founder in Scotland; and the printer asked him whether he could do anything to remedy the defect. He immediately answered, that it would be more easy to cast plates from pages when composed in moveable type; and he undertook to produce, and very shortly did so, a specimen of his new plan, and not long afterwards made arrangements with a capitalist to advance the requisite funds. The latter failing to perform his part, Ged made a similar contract with a London stationer, in conjunction with whom he made many attempts; but being repeatedly thwarted, he parted from his partner, and made proposals to the universities and the king's printers to stereotype Bibles and prayer-books. These all entered into the scheme with some eagerness, and some works were produced quite equal to the ordinary printing of the day. Nevertheless, so much ignorance and prejudice prevailed amongst the workmen, and others interested, as they imagined, in the old system, that the undertaking was soon abandoned, and Ged entered into several subsequent arrangements, in which he was equally unsuccessful; a type-founder, in particular, causing such obstructions that the art made no progress. Ged died, therefore, before he had met with any encouragement; nor did his son succeed better, although, as the practicability was made more manifest, the very parties who had rejected his plans subsequently made extensive use of his plates. What was Ged's method of stereotyping is unknown, as he kept it private; nor did his partners fully participate in the secret.

Practical Printing. Stereotyping.

Fifty years afterwards, Mr Tilloch made a similar invention; but, from private circumstances, the design was laid aside, not however before several volumes had been printed from his stereotype plates at the press of Mr Foulis. Some years after this Lord Stanhope engaged an ingenious London printer, Mr Wilson, to prosecute the invention; and after many trials, the noble lord's ingenuity succeeded in bringing the art into perfect use.

Mode of stereotyping.

When a work is expressly intended for stereotyping, the type used should be somewhat different from that commonly employed. The letter should be cast without any shoulder, but should rise in a straight line from the foot; the spaces, quadrats, and leads should be of the same height as the stem of the letter, because the less the cavities in the page, the less chance there is of any of the mould breaking off and remaining in the form. The page having been composed in the ordinary manner, and very carefully corrected, is imposed in a small chase with metal furniture, and the whole is placed within a moulding frame, somewhat less than half an inch higher than the type. The surface of the type is then rubbed with a soft brush holding a small quantity of very thin oil.

The plaster of which the mould is formed is the common material of which statues and busts are cast; it should be of two degrees of fineness, and may be easily purchased ready prepared. These having been carefully mixed, a small portion of the finer quality is gently poured upon the surface of the page, and softly worked in with a brush, care being taken that every portion is fully covered, and that no air-bubbles remain in any part of the letters. Immediately a larger quantity of the coarser plaster is poured on and spread over the previous layer without disturbing it; a straight-edge is then passed over the moulding-frame, clearing away the superfluous plaster, and leaving that within the frame of uniform thickness. It is then left to set. When sufficiently dry, the moulding frame is raised, and the mould with it; the mould is then dressed, and placed in an oven until it be perfectly dry, and raised to an adequate temperature for the casting. The oil with which the page is rubbed prevents the plaster from adhering to the type.

The melting-pot is a square vessel of iron about two inches and a half deep, having a separate lid, of which the four corners are cut off, the inner face being carefully turned, the outer face turned hollow towards the centre. A floating plate, of which the upper surface is turned, is placed at the bottom of the pot. Over the melting-pit is a crane with a rack, upon which a pair of nippers are made to run. These lay hold of ears upon the melting-pot, closing with its weight, and opening when relieved. The metal does not differ from type-metal, and must be sufficiently fluxed to flow easily, but not made too hot, or it will prove brittle. The melting-pot having been heated in the same oven with the mould, and consequently to the same temperature, the latter is placed within it, the face being turned down upon the floating-plate. A bar or other piece of iron is screwed down upon that part of the lid which is turned hollow; and the whole being suspended by the rack and crane, is swung over the melting-pit, and gradually let down into the metal, which flows gently into the pot through the openings left at the corners. The metal flowing slowly in gradually expels all the air; the mould immediately rises to the inner surface of the lid; the floating-plate, being specifically lighter than the metal, rises also to the edge of the mould; consequently the metal which has run in between is of the exact thickness of the depth of the mould, the upper surface being the field

Practical Printing. Stereotyping.

upon which are the casts of the type, the under surface the smooth face of the floating-plate, and the rest of the melting-pot being filled with metal. The pot is allowed to remain immersed ten minutes or a quarter of an hour, that is, until the air is supposed to be perfectly expelled. The pot is then drawn up, and swung to a board resting upon a trough of water, and there allowed to cool. The cooling is a process requiring much care and attention. It is obvious, that unless the whole mass cool equally, the plate will be warped, and consequently spoiled; it is equally clear that the heat will more readily radiate at the corners, and consequently that the centre will remain fluid after the other parts are set, and that the contraction must be unequal. This is provided against by the lid having been turned hollow in the centre, and it will therefore allow the metal under it to cool more rapidly. The mass having been turned out from the pot, the metal under the plate is separated by a smart blow or two of the mallet; the floating-plate will be readily disengaged, and the mould be removed from the cast. Some defects will invariably be found in the new plate; but these are removed by the picker, who goes carefully over it, clearing away the picks from the face of the letter, and deepening the larger white lines with a graver, that they may not blacken in working at press; for it must be remembered, that the quadrats and spaces used in stereotyping are higher than those in moveable-type printing. If the face of the plate has cooled evenly, and it is in other respects a successful cast, it is placed, the face inwards, in a turning lathe, and the back rendered a plane parallel to the face; the margins are then squared, and the edges flanched. The plate is now ready for use.

A great improvement in the stereotype art was a few years ago introduced by Mr Thomas Allan, printer in Edinburgh, into his establishment, by which a number of plates are cast at once, whilst the risk of broken casts is considerably lessened. This is effected by means of a pot sufficiently deep to contain moulds placed in a perpendicular position. The pot is an oblong square cast-iron box, widening towards the mouth, and having placed inside, at each end, a wedge-like block, of which one face is parallel to the side, while the other is perfectly vertical. On the vertical side are perpendicular grooves, at distances rather greater than the thickness of the stereotype moulds. Into these grooves are inserted plates of malleable iron, by which the interior of the box or pot is partitioned into spaces sufficiently wide to admit with ease the plaster moulds. The moulds, when baked, being inserted into these spaces, a cross bar of metal is placed over the top, instead of a cover, which serves to prevent the moulds from being raised by the liquid metal flowing beneath them; and it is then suspended upon the crane, and dipt into the metal-pit in the usual way. By this method not only are the moulds saved from all risk of breaking by being placed horizontally and pressed between the two broad surfaces of a float-block and cover, as in the method of single-page casting, but a number of plates are produced at one cast, and thus additional celerity is combined with greater certainty of sound plates. The plates of the ENCYCLOPÆDIA BRITANNICA, which is the most extensive work ever stereotyped, have been for the most part produced by this process, in pots containing each five moulds; and it is especially advantageous for large plates, the risk of breakage by the old method increasing in a greater ratio than the increase in the size of the page.

The plates are sometimes mounted upon blocks of mahogany, the height of which is the difference between the thickness of the plate and the height of the type. These blocks are furnished with brass sides, the upper part of which is turned over so as to take hold of the flange of the plate. Many attempts have been made to accommodate these blocks to the varying sizes of the plates, by forming them in portions; but, where much stereotyping is done, the plates are usually cast to uniform sizes, corresponding blocks being kept ready for use. An ingenious plan has been devised to remedy this inconvenience, by a series of hollow squares of type-metal of the requisite height and of different sizes, by means of which pages may be easily composed to any required size, from one pica m upwards; the plates being fastened on by brass holders. At a small expense once incurred, the stereotype printer may furnish himself for ever.

Practical Printing. Stereotyping.

There are many smaller instruments requisite, which it is quite unnecessary to mention. The founder requires some practical skill, which, however, it is not difficult to acquire. The excellence of the casts will depend upon the personal knack and observation of the founder. The metal for stereotyping is generally purchased prepared for use, in preference to melting down old type, the type-founders allowing much more for it in exchange than the metal can be purchased for. The price of prepared metal is about 40s. per cwt. The following, however, are proportions which may be used when the prepared metal cannot be procured:—

1. From five to eight parts lead, one of regulus, one fiftieth of block-tin.
2. One seventh of pure regulus, six sevenths of lead. The best lead is that which comes from China, in the lining of tea-chests.

The mixing of the lead is exceedingly injurious to the workman, and should be avoided wherever it is possible. The foundry should be thoroughly ventilated, as the fumes from the melting-pit, and the moisture and smell of the drying oven, are very noxious.

An extravagant notion prevails, especially amongst persons not experienced in the mysteries of printing, of the exceeding economy of stereotyping; it would therefore be of advantage to give a fair view of the case. On an average, the cost of stereotyping may be taken as the same as that of composition, or even higher. It is quite clear, therefore, that if the first edition of a work is stereotyped, the speculator at once incurs the expense of *printing* two editions, minus the press-work. The consequence is, that if his untried book does not succeed, he very much increases his loss, or at best he increases his chance of loss, because many books that just get through a first edition never arrive at a second. Therefore the first edition of a work should never be stereotyped, unless indeed the work be of such a nature as to insure a general sale at a low price, as, for instance, Ready Reckoners, Tables of Interest, and such like. Again, what work is there so perfect as not to require some alteration and amendment in a new edition, which, in stereotype, is practicable only to a limited extent. Supposing, next, that the great demand for a work is ascertained, that the matter is sufficiently corrected to require no farther alteration, and that the work has been stereotyped; the owner must wait until the copies printed from the types from which the casting has been made are sold, before he has occasion to make use of his plates. On the one hand, suppose that he print sufficient for four years consumption; and on the other, sufficient for one year at the same rate. The account will stand thus:—

Type.

Cost of composition, 25 sheets, say	L.50	0	0
Press-work, 4000 copies, 200 reams, at 7s.	70	0	0
Paper, 200 reams, at 20s	200	0	0
	L.320	0	0
Interest on average of two years (allowing for periodical return of capital)	32	0	0
	L.352	0	0

Practical Printing. Stereotyping.

Stereotype.

Cost of stereotyping	L.50	0	0
1st year, Press-work of 1000 copies, 50 reams, at 9s	22	10	0
Paper, 50 reams	50	0	0
	L.122	10	0
Interest, 1 year 6 months, plates	3	15	0
Ditto, 6 months print and paper	1	16	0
	L.128	1	0
2d year, Print and paper L.72 10 0			
Interest, plates, 1 year 2 10 0			
Do. print and paper, 6 months 1 16 0			
	76	16	0
3d and 4th year	153	12	0
	L.358	9	0
Balance *against* stereotyping	L.6	9	0

Second Four Years.—Type.

Composition from reprint copy	L.43	15	0
Press-work, 4000 copies, at 7s.	70	0	0
Paper, 200 reams, at 20s.	200	0	0
	L.313	15	0
Interest, average 2 years	31	17	6
	L.345	12	6
Four editions from plates, and interest as before	307	4	0
Balance in *favour* of stereotype	L.38	8	6
Cost of first edition, type	L.352	0	0
Ditto second ditto.	345	12	6
	L.697	12	6
Cost of eight editions stereotype	664	13	0
Balance in favour of stereotype at the end of eight years	L.32	19	6

without taking into account repairs and incidental expenses which would be incurred in stereotype *only*, and also not reckoning the produce of overplus copies, which would be proportionately greater in type.

If the type be small, and the composition expensive, it would be considerably in favour of stereotype; but on the *per contra* would be the greater wear and damage of the plates.

Such is a fair statement of the pecuniary profit and loss of type and stereotype; but there are other considerations. Every edition from the plates must be in the same type, without any of the improvements that skill or fashion may require; whereas every edition from type may be varied to the taste of the day, and any defects in composition or making up remedied. Every edition from the plates must also get progressively worse and worse. It is asserted that no injury can accrue to the plates, but the fact is precisely the reverse; for these plates are particularly liable to injury, from their weight and brittleness, from blows, from picks and batters, which will happen notwithstanding the greatest care, from fractures at the edges in placing on the blocks or raisers, and many other fortuitous circumstances. These it is difficult to remedy, and, when remedied, they present a most unsightly appearance, sometimes from the same fount not being at hand, or sent to the melting-pot (and great changes occur in the types of a printing-office in the course of eight years), sometimes from the new letters not standing of the same height, which is a common fault, and always from their not standing in line. Again, printing from plates never looks so well as that from type; and the most inexperienced eye may instantly detect the difference, even in the first edition.

Practical Printing. Stereotyping.

Nevertheless, in some cases stereotyping is of great advantage; but chiefly in books of numbers, in which it is of the utmost importance that every figure should be correct. In this case the proofs must be read again and again, until the correctness is unquestionable, then stereotyped; and there is no fear of alteration from the error of compositors or carelessness of readers, but the book remains the same for ever. Such works also are most expensive in getting up, and the cost of composition very much exceeds that of stereotyping. Books of logarithms may be especially mentioned, tables of longitude, indexes to maps, and other works, which, being once written, remain unchangeably the same: or where it is found expedient to have duplicates of the work, as when immense numbers are required, and it is necessary, for speed, to work on double-sized paper; such, for instance, is the Penny Magazine, from which, when once composed, a cast is taken, and the original and cast are worked side by side at the same moment, producing two copies instead of one, in which case there is another advantage, for the casting does not exceed the cost of composition, and, when worked, the stereotype remains without further expense for another edition: again, where it is expedient to send duplicate plates to a distance to be worked, thereby saving the expense of carriage, and some time; as in the Penny Magazine, where several casts are taken, and one sent to America, another to Germany, &c.; in Chambers' Edinburgh Journal, where one cast is worked at Edinburgh, and another in London; in Richardson's Dictionary, where one cast is used by the London publisher, and another in the United States.

Wood-cuts may be stereotyped with great advantage, for a small cut which has cost several guineas to engrave may be multiplied indefinitely, and that at a cost of a few shillings.

No printer should stereotype who wishes his type to be a credit to his house. The wear of material in casting is miserable; the gypsum is at best a fine powder, and grinds away the edge and face of the letter when rubbed in with the brush in a frightful manner. The letter can never be entirely freed from the plaster, and will present a very dirty appearance ever after. The wear of a fount of 1000 lbs. weight, returned six times from the foundry, is greater than would occur in six years' constant fair usage; besides which, the high spaces, quadrats, and leads, are all extra expenses, for which the economical bookseller makes no remuneration whatever.

School-books are most frequently stereotyped, in ordinary cases with the advantages and drawbacks above related. Suppose, however, a Spelling Book or Primer, say Guy's, selling from forty to fifty thousand copies yearly, in which it might be supposed that stereotype would be of infinite advantage. For such a book, stereotype plates would not last, even in decent condition, four years. Calculate the cost, without interest, the money being constantly returned.

Type.		*Stereotype.*	
Seven sheets, say	L.40	Stereotyping	L.14
Working 560 reams, at 5s.	140	Working 560 reams at 6s.	168
Paper	490	Paper	490
	L.670		L.672
Rent to be paid to printer to keep type standing, say one fourth	L.10		
Print and paper	630		
	L.640	Print and paper	L.658
Cost in four years	L.2590		L.2646

Balance against stereotype, L.56.

Practical Printing. Polytypage.

at the end of which time the types must be set up again, and new plates cast. But any printer will keep standing a work of which such numbers are required, without any charge whatever; and every worn or battered letter may be taken out and replaced, so that every edition will be in perfect condition for generations.

The plan of stereotyping Bibles and prayer-books has been nearly abandoned, and the entire sheets are kept standing in moveable type, at incalculable expense, by the Queen's printer, the University of Oxford, and, it is believed, that of Cambridge. Before every edition, however, is worked, every sheet must undergo a careful reading.

Of Polytypage.

The ingenuity of our lively neighbours the French has been excited for nearly a century in devising a speedy and cheap mode of making solid plates, either in sequence or in substitution of moveable type. Many considerable improvements in stereotyping are to be ascribed to these artists; but stereotyping has never been a favourite with them, and they have rather exerted their invention in a series of experiments, which may be classed under the general name of polytypage.

The first experiment noticeable is that of Dr Franklin and M. Rochon; but although curious, it is not polytypage in the common meaning, or the art of producing letters in relief. But it is very ingenious, and is the first step in that art. Franklin made an exceedingly glutinous ink, with which he wrote upon thin paper, in the ordinary manner, but rather coarsely. This writing he powdered with pounded emery or iron filings, and it was then placed between two plates, of which the lower one was exceedingly hard, and the upper one extremely soft. These were then passed between a rolling press, when the iron-filings or emery sunk into the softer plate, from which impressions might be taken in the manner of copperplate printing. The effect, as may be supposed, was exceedingly rough and unsightly. M. Rochon then proposed to write with a steel point upon a prepared plate, and bite in the tracing; this would give impressions in reverse, which, whilst the ink was yet fresh, were to be pressed strongly between clean paper, the set-off upon which would be fit for use. By this unskilful means Rochon says many private works were circulated; but it is rather doubtful. M. Rochon next undertook a much more likely project, the stamping of punches, somewhat like types, into soft metal, in the same order and with as much rapidity as they are composed in ordinary printing, with mechanical contrivances to make the impressions stand well, and also to insure the even depression of every letter. These stamped plates were originally intended to be printed by the rolling press; but afterwards the scheme was entertained of taking a cast from the plate in type-metal, and printing from that. It does not appear that this idea was brought into practice.

In 1780, Hoffman, a German, residing in France, brought stereotyping to considerable height; but, not satisfied with his success, he made many ingenious efforts in polytypage. He first used Rochon's method; and whilst he was thus engaged, a practical printer, named Carez, started a new method, which Hoffman afterwards pursued. The page, after being composed in the ordinary manner, was attached, with the face downwards, to the under side of a heavy block of wood, suspended from a long beam. Immediately under the page was an anvil, on which was a tray of oiled paper, into which the workman poured a portion of melted lead, attentively watching the cooling. When the metal seemed on the point of setting, the page, block, and beam, were brought down with a very smart blow, forcing the face of the type into the cooling metal, and producing a very sharp mould; which again was made to take the place of the type upon the block, was struck in a similar manner upon fused metal, and would thus, as was said, produce a perfect and excellent stereotype plate, which, having been properly dressed at the edges and back, was affixed to the usual wooden raiser; nor does there seem any reason why more than one cast might not be made from the same mould. Carez appears to have practised this art to some extent, and successfully.

Hoffman was no doubt acquainted with this invention, for his next scheme was a modification of it. In order to avoid the expense of composition, he prepared a series of punches, consisting as well of single letters as of common French terminations, which, with a very ingenious instrument, he pressed into a thin layer of prepared clay; and this, when baked, he stamped upon a portion of fused metal, in Carez's manner, producing a stereotype plate. It must be quite evident that in practice this could never answer, because the lining of the letters, and the exact plane of the surface, cannot possibly be achieved with that nicety which is indispensable in printing. Unfortunately, also, the expense and trouble of stamping in the punches separately must be considerably greater than that of composing types, even were it practicable, which it does not seem to be.

In 1791, M. Gegembre printed the fifty sous notes of the Caisse Patriotique upon an improved plan. He caused the whole print of the notes to be engraved in relief upon a plate of steel, the letters and ornaments being run together in a manner impracticable with separate punches; and this engraving he pressed into a plate of alloyed copper, from which stereotyped casts were taken by Carez's process. Any number of these casts could be taken from the copper mould, as indeed was necessary, since, from the softness of the metal, they were rapidly worn out; and if by chance the copper mould became injured, a new one could be readily made from the steel engraving.

When the revolutionary government commenced issuing assignats, it became necessary to have an immense number of plates to work the enormous quantity of these documents required. A design having been approved of, artists were employed to engrave *three hundred* fac-similes. Of course, if three hundred so-called fac-similes could be engraved, there could be no difficulty to other artists in engraving another hundred, nor could even the bank-officers tell which was a forged fac-simile and which were engraved by their authority. The consequence was utter want of confidence in the government paper. To remedy this, the committee of assignats caused many experiments to be instituted for the production of plates which should be not only imitative and similar, but *pro re* identical. The plan adopted was the engraving a plate *in intaglio*, from which copper punches were obtained *in relief*, and called *mother-punches*. From these *daughters* were struck, which were perfect fac-similes of the original engraving, and were worked by the roller-press in the manner of copperplates. Guillot, the director, reported, that from one engraving, for the 400 livres assignats, he had struck or polytyped 897 *mother-punches* and 1487 *daughters*, of which number only 190 were defective; of the plate for the fifty livres assignats, 4760 mother-punches and 7684 daughters, 1140 of which were defective. The chief defect was, that frequently the air compressed in the mould of a single letter would effectually prevent the fused metal sinking to the full depth, and thus there would be no letter at all upon the plate. Upon the suppression of assignats this establishment was broken up; but some of the plates and matrices are in the public repositories of France. In printing the tickets of the national lottery, Gatteaux obtained the assistance of Didot the printer, whose firm soon afterwards issued proposals for printing polytyped editions of the classics, at very reduced prices; and in 1798 they issued an edition of Virgil, followed by many other works, remarkable for their neatness and cheapness; so that their

Practical Printing. Polytypage.

plans may be pronounced to have been completely successful. The process differs little from those before described.

Types of the usual form, but of very hard metal, being composed, are placed within a steel box, with the face downwards upon a plate of metal, and pressed slowly and smoothly, but with great force. Since, therefore, all the letters are forced simultaneously and evenly into the plate, no uneven impression takes place. They are then disengaged, and any faults are amended by striking in a punch of the defective letter. From the matrix thus obtained plates in relief are cast, from which the paper is worked, the matrix being put away to strike other plates if needed.

M. Héran, Didot's partner, having separated from the firm, applied himself to the improvement of the art, and hit upon a novel and ingenious mode. This was the formation of a set of types the very reverse of the common, viz. instead of the letter being in relief upon the shank, it was in intaglio; therefore every separate letter would be a die, and instead of the letter being reversed, it would stand as read on the paper. The spaces, quadrats, leads, &c. were of the exact height of the type. These were to be composed like types, so that the entire page would present the appearance of a plate of copper into which words, &c. had been punched; the matter was to be read in the metal without a proof, which, as the words read from left to right, was matter of no difficulty. Upon the matrix thus composed fused metal was to be pressed, which would obviously form a complete plate fit to be printed from; and the operation could be repeated until as many plates were struck off as were required. M. Héran first endeavoured to cast his types in a mould like that used by letter-founders; but the metal proved too soft, and he afterwards struck punches into shanks of copper of the required size. Works executed from such plates are of remarkable neatness, and the process may be pronounced of very great utility, although, as far as known, it has never been introduced into England.

Towards the end of the eighteenth century, Professor Wilson of Glasgow, being engaged in a series of experiments for making etchings upon glass with fluoric acid for the purposes of art, thought it possible to make polytypes of glass from engraved copperplates. In this he in some degree succeeded, having executed several polytypes in intaglio from moulds of copperplates, and in relief from woodcuts; but it cannot be said to have been practically successful, the lines not having any degree of sharpness in either case, whilst the brittleness of the material would be a decided objection.

Messrs Heath, Perkins, and other ingenious men, having turned their attention to the prevention of forgery of bank-notes, have produced many excellent plans, amongst which is that of Mr Heath, of taking the impression *en creux* from an engraving of hardened steel upon a cylinder of soft steel afterwards hardened, from which cylinder any number of the plates, fac-similes of the first, may be readily executed. This plan does not differ in any degree from that of Hoffman and Carez, save in respect of the cylinder; but the manner in which the engraving is executed on the original steel by the lathe is most astonishing. These plans have not been adopted by the Bank of England, but most country banks of issue have greedily adopted this almost complete safeguard against forgery.

Mr Brunel has lately invented an ingenious modification in the making of moulds, which consists in spreading a coating of shell-lac upon a plate of iron, and hardening it in the fire. This is then dipped into the melting-pot, and receives a thin covering of metal, and is then pressed upon the types. The impression produced thereby is most beautiful. The lead can never sink to any depth in the hollows of the page, there are no picks or other soils to clear away, but it may be doubted whether the lead would form a very good mould to cast from.

Practical Printing. Printing in Colours.

Printing in Colours.

One of the most beautiful aids to typography, the art of printing in colours, has been entirely neglected in this country; at least as far as relates to the embellishing works of ordinary excellence with vignettes, capitals, tail-pieces, and other devices of fancy, in beautiful tints, in the manner of the early typographers. It is true that ingenious artists of the present day have exhibited much skill in illustrating works of natural history, and have shown wonderful genius in publications professedly connected with the fine arts; but, as far as regards the average printing of the day, it is entirely neglected. This may very easily be accounted for. To print in two colours occupies more than twice the time necessary to print in one; and it also requires more skill and ingenuity. These unfortunately must be paid for; and this pecuniary consideration is sufficient to banish from our pages this lovely art. So did not our forefathers; *they* took pride in choosing the most tasteful designs, the most harmonious colours, to illuminate their productions, and beguile the reader into study by the illusive charms of gold, and blue, and crimson. Fortunately, either time was of little value, or the exclusive possession of the market enabled them to demand remunerating prices for the time thus well bestowed; but in the bustle and competition of our more mercantile days, time is money, and blue and gold, scarlet and green, give way to the equally useful but infinitely less beautiful uniformity of unredeemed black. To a country printer, however, some knowledge of colour-printing would be of infinite advantage, because, as his founts of type are more limited, he can create unlimited variety by a judicious use of colours in job-work: moreover, as he has usually much more time upon his hands, his ingenuity would have ample scope for the production of small works of *vertù*, in a taste which cannot be indulged by the denizen of a busy metropolis.

Except in the execution of works of a very high order, and the imitation of intricate and delicate patterns, printing in colours requires no addition to the ordinary accomplishment of printing, other than considerable ingenuity, and a little practice in preparing the colours. The latter may, it is true, be purchased of the ink-maker prepared for use; but the charge for them is enormous, and they require constant replacement, whilst it is not possible to have on hand every variety of tint. By the purchase of the most simple materials from the oil-shop, the ingenious printer has at his hand every colour that fancy can require, at the most moderate cost, without waste or delay. The appliances are few and cheap: a muller, a marble slab, and a palette-knife; the materials, a can of printers' varnish, to be purchased of the ink-maker, which will keep any length of time, and the raw colours hereafter given, which may be purchased from time to time; care, however, being taken that they are of the best quality, or they will fade and turn rusty in a short time, and be a deformity instead of an ornament to the work.

Useful tints of RED may be prepared of orange lead, vermilion, burnt sienna, Venetian red, Indian red, and lake. Vermilion is the most brilliant of these reds; but its beauty depends very much upon the particular parcel used. The pale vermilion is best for a bright tint, as the dark, when mixed with the varnish, produces a dull red. Orange lead and vermilion ground together produce a very bright tint, which is more permanent than vermilion alone.

YELLOWS are prepared with yellow ochre, gamboge, and chromate of lead. Of these, the brightest is the chrome; yellow ochre, when mixed with the varnish, produces a very dull tint.

Practical Printing. Printing in Colours.

BLUES are made from indigo, Prussian blue, and Antwerp blue. Of these, indigo is exceedingly dark, and not very easily lightened. Prussian blue is a very useful colour; Antwerp blue is very light.

GREENS may be produced from a mixture of any of the blues and yellows, as gamboge and Prussian blue, chromate of lead and Prussian blue. These may be mixed in any proportions until the required tint is produced; but it must be remembered that the varnish has a considerable yellow tinge, and will produce a decided effect upon the mixture. With a slight portion of Antwerp blue it will, without the mixture of any of the yellows, produce a decidedly greenish tinge.

PURPLES of any degree of richness are made by judiciously mixing reds and blues.

Sæpia produces a nice brown tint, burnt umber a very hot brown, raw umber a much lighter brown, bistre a brighter still. Neutral tints may be obtained by mixing Prussian blue, lake, and gamboge. In fact, every pigment that painters can use can be used in printing, avoiding, as much as possible, all heavy colours. In truth, if the printer is desirous of imitating any particular colour, or of producing any particular tint, he cannot do better than consult the nearest artist in oil or water colours (oil in preference), or in default of that, the neighbouring house-painter.

The necessary colours having been procured, the method of preparing them is very simple. Each must first be well ground by the muller upon the slab, even although they may have been purchased well powdered. The colour should then be well mixed with the palette-knife with the varnish, until the pigment has attained the required consistency, which will vary with the quality of the work to be executed; for if it be a posting-bill or coarse job, the ink should be very thin, and consequently a much larger proportion of varnish should be used. If, however, the work be a wood-cut or in small type, the pigment should be made as thick as possible. If the colour required be a compound, the predominant tint should be first mixed with the varnish, and the lighter tint added in small quantities, until the exact shade required be produced. Thus, if the colour be a dark green, the blue should be mixed up first, and the yellow added; but if it be a very light green, then the yellow should be first applied, and the blue added. If the tint desired be exceedingly light, it will be found that the quantity of raw material to be employed will not make the mixture sufficiently thick to be applied to the type or wood-block: in this case whitening is added to thin colours, and dry white lead to the heavier in considerable quantities, which must be adjusted in the course of mixing. To insure thorough combination, the mixture should be scraped into a corner of the slab, and a very small portion of it spread with the palette-knife, and well ground with the muller until no specks or lumps appear, then scraped up and placed in another corner. This should especially be done when white lead is used, as it will be found that every little lump when crushed will produce a white streak upon the slab. If this be not carefully done, independently of its tendency to clog the type, it will very materially alter the tint. When the pigment seems sufficiently mixed, it is better to bray it out with the muller instead of the usual brayer, and grind again each particular portion immediately before it is used. Colours may be worked either with a ball or a roller. If the job be large and coarse, and the ink consequently thin, the roller will answer every purpose; but if it be small, and requiring much nicety in the manipulation, decidedly with a ball; but in either case the ink should be well distributed, and the form well beaten or rolled. When two or more colours are employed, they must be worked at as many different times. In this case extreme nicety in the register and justification is required, in order that every colour may fall in its just place, without overlaying any other tint employed in the print. This would be a great dis-sight in any case, but most especially where the composition of colours would produce a third; as, for instance, if any part of a blue line should unfortunately fall upon a yellow, a green outline would be the result. The simplest way to guard against this is to have the wood-blocks all cut to precisely the same size, with the print in the proper place upon each; when, therefore, the first colour has been worked, the form is unlocked, the block taken out, and the second block inserted; it then falls at once into its proper position. If the form consist of type, each line should be carefully composed in its proper body, that is, if three colours be employed for as many different lines in *Pica*, *Small Pica*, and *Long Primer*, the one to be first worked should be composed in pica *letters*, the other lines in small pica and long primer *quadrats*. When the second line is to be worked, its quadrats should be taken out and letters inserted, while the type of the first line should be removed and quadrats substituted; and so of the third line. The points on the tympan must never be moved. It is clear, therefore, that if the paper be placed upon the same point-holes as before, and if the form has never been moved, the new line cannot fail to fall into its proper place. The illustrative Plate CCCCXIV. has been worked upon this plan; the black, being the largest body, was first printed, as it afforded the best guide for subsequent working. The blue was next worked, because it was much easier to adjust it to the black, than to adjust the red so exactly that the blue should precisely surround it and yet not infringe upon or retreat from the black, while there would be no difficulty in making the other red portions fall in their proper places. In these cases the paper must never be suffered to dry; indeed the sooner each colour succeeds the other the better. If it be covered with a wet blanket, and the edges well sprinkled, the danger will be little; but if it should dry and shrink in the slightest degree, it will be impossible to obtain register. For printing red-letter days in almanacs and the rubrics in prayer-books (an almost extinct practice), an especial type is used called rubrical; it is cast about an m higher than ordinary type. The black is first worked, quadrats having been inserted in the places of the red letter, which are subsequently withdrawn, and the rubrical type inserted. But as, in so small an insertion in so large a body, this process does not attain any very good register, and is expensive withal, the red-letter days have been abandoned, and some other distinguishing type (generally old English or black) has been substituted, which sufficiently indicates the day. It would not be possible here to give sufficient instructions to enable a printer to execute landscapes, portraits, and other delicate subjects, in various colours and shades. The chief difference between this and other colour-printing consists mainly in the superior individual skill and ingenuity of the artist, the excellence and truth of his engravings, and the superiority of his appliances. In truth, before the printer can produce any great effect, he must be excellently qualified as a painter, which it is not the province of an article on printing to teach. It will be sufficient to state, that the lighter and more extensive tints, and especially those in which transparent colours are used, are worked first, the colour being gradually deepened by successive blocks, until the required effects are produced; and that the outline is printed last, to give sharpness and finish to the design. The curious reader is referred to Mr Savage's beautiful book on Decorative Printing, and to the many admirable productions of Mr Baxter and Mr Vizetelly. Mr Charles Knight has taken out a patent for a new process in printing in colours, the principle of which consists in a new mode of obtaining register of the different colours. It is understood that *all* the colours are printed before the sheet of paper is taken from the tympan, but not at one impression.

Practical Printing.

The outline is printed at a second operation. The means whereby this is effected may be learned as soon as the specification is enrolled. If the plan succeed (as yet it is but imperfectly tried), it will materially reduce the cost of coloured prints of all descriptions, and especially of maps.

Gold.

There is no difficulty in printing in gold; it is within the power of any typographer. The type is composed and made ready at press in the usual manner. A quantity of raw or burnt umber is mixed with printer's varnish, to the same consistency as it would be were it intended to be used as ink; but this mixture is then compounded with a considerable quantity of gold size, the same as that used by gilders and japanners. The first mixture is necessary, because it has been found that the umber will not combine with the size. The type is then rolled with this compound, in the same manner that ordinary ink is applied, and the impression is taken upon the paper. Leaf-gold is then laid over it with a piece of wool, and pressed slightly upon it. When the varnish has had time to set, a piece of wool is rubbed roughly over the part printed, and the superfluous leaf is thereby removed, leaving the gold adhering to the varnish. The sharpness of the print will vary with the judgment of the printer in the quantity of sizing applied to the type; for if the press-work be bad, the print will be bad also. For inferior gold-printing bronze powder is extensively used. For this the varnish is made very much thicker than for gold; the method of printing is the same; but after the impression has been given, the powder is brushed over the print, and will adhere thereto, whilst the superfluity may be easily removed. In printing the golden Coronation Sun with this powder, a very distressing disease arose, the hair became perfectly green, and the men were very seriously affected; great caution should therefore be taken that particles of the powder be not allowed to fly about the room. Dutch gold cannot be used as a substitute for gold leaf.

Bank-Notes.

Bank-notes.

The numbers of bank-notes are printed by an exceedingly ingenious process, which, being regulated by machinery, makes it impossible to commit any fraud by printing two notes with the same number. The apparatus consists of a series of brass discs, of which the rim is divided by channels into projecting compartments, each containing a figure. The numbers 1 to 9 having been printed in the course of the revolution of the first disc, and this disc having returned to figure 1, the second disc comes into play and presents a 0, and the two together therefore print 10. The first disc now remains stationary until, in the course of the revolution of the second disc, the numbers 1 to 19 have been printed, when it presents the figure 2, and does not again move until another revolution of the second disc completes the number 20 to 29. Thus the two discs proceed until 99 notes have been numbered, when the third disc comes into operation, and, with the two first, produces 100, consequently the first disc performs one hundred revolutions to ten of the second and one of the third. The notes may be numbered indefinitely by this process, without the possibility of error, the machine, meanwhile, being its own check.

Printing Presses.

Printing presses.

In the description of the Stanhope Press it has been stated that many other presses upon different principles have recently been invented; most of these, however, contain some application of the Stanhope power. The most powerful, but the most expensive, of these is the Columbian or Clymer Press. The power in this is acquired by an extremely powerful lever, the pivot of which is in the top of the near staple: it passes entirely over the press, and is pulled down by a bar inserted in the near side, connected with the Stanhope coupling bar, &c. The platten is attached to the centre of the lever, therefore the impression is perfectly vertical. The principle may be popularly understood by balancing a ruler upon the edge of a piece of wood, holding firmly one end in the left hand, and pressing down the other with the right: indeed a very fair impression of a small wood-cut may be obtained by placing it with the face downwards upon a soft pad, fixing one end of a bar of wood under a staple, and pressing down the other.

Practical Printing. Printing Presses.

Cogger's Press is very powerful. Its principle is a sector or piece of curved steel, so arranged that the lower portion is more curved than the upper; a steel stud traverses upon this. When it moves over the lower and more inclined portion of the sector, it brings down the platten with great rapidity; but in traversing the upper portion, as it presents a less inclined plane, the power is consequently much increased, and is greatest, very great, at the pinch. These presses are complained of by the workmen as being very slow; but the greatest objection to them is, that in making short pulls a ledge is worn upon the sectors, which is a great obstruction to a long fair pull: with proper attention by the pressman this would not occur.

The *Albion* Press, manufactured by Cope's executors, is a general favourite for its exceeding lightness; it runs very easily, the pull is short, the power great, and the means whereby it is attained so simple that there is little fear of the press getting out of order; it is very easily taken down for cleaning, and put up again. The power is gained by causing an inclined piece of steel to become perpendicular; in so doing the platten descends, and the impression takes place at the moment the piece of steel is assuming its upright position.

Cope and Sherwin's *Imperial* is another very excellent press, upon principles which do not greatly differ from the Albion: they are very numerous.

In Harrild's Press the power is obtained by the straightening a knuckle or elbow-joint, in precisely the same manner as the bent arm is straightened. Being of very expensive construction, they have not obtained great sale.

Printing Machines.

Printing machines.

As long as the thirst for literature was confined to books and a few periodicals of limited sale and size, the ordinary printing presses sufficed to supply the demand; nor was it discovered that any further speed was requisite, until the increased facility of conveyance, and the important events at the close of the last century, created a demand for news, that the utmost exertions of the printers were unable to supply; for the attempt to increase the speed by the composition of two distinct forms of type would avail little, so long as the presses could turn out only two hundred and fifty or three hundred sheets each per hour. Accordingly, for this branch of the art were the first machines projected. Many schemes were proposed for accelerating the movements of the press; but the first attempts at anything like the machine afterwards introduced were made by William Nicholson, a gentleman connected with periodical literature, who took out a patent about 1790, for a printing machine, of which the chief points were the following: The type was to be fixed upon a cylinder, being cast narrower towards the bottom, in order, as it were, to radiate from the centre of it. This cylinder, with its type, was to revolve in gear with another cylinder covered with soft leather; an inking apparatus was applied to the type-cylinder, and the paper was to be impressed by passing between the two; most of these plans were, when modified, adopted by after-constructors. This machine was never brought into practice. König, an ingenious German, was the next who un-

Practical Printing. Printing Machines.

dertook to construct a machine; and, having made considerable advance in his plans, obtained a contract with Mr Walters, the proprietor of the Times newspaper, for manufacturing two for that journal. In these Nicholson's plan was so far altered, that the type was laid upon a flat surface, and the impression was given by their passing under a cylinder of great size. He afterwards invented a machine in which the sheet was printed on both sides before it left the machinery; but, in both, his arrangements for the equal distribution of the ink were so complicated and clumsy, consisting of not less than forty wheels, and the works of every part of the machine so intricate, that it never came into practical use. The first really useful machine was constructed by Messrs Applegarth and Cowper, being an extensive modification of that of König; its principle improvement consisting in the application of two drums between the impression-cylinders, for the purpose of insuring the register of the sheet, by retaining it, after the impression of the first form, just so long that it may pass on to the second cylinder in exact time to be impressed thereby upon the second form; and of the distribution of the ink upon a plane surface, instead of by a complication of rollers, by which König's monstrous machinery was got rid of. These machines are now in general use.

For newspapers, machines are generally made to work but one side at a time. It is manifest that a machine will work a much greater number (more than double) of one form than of two; and that the machinery will be lighter and less expensive, and of course require less motive power. One form, therefore, of a newspaper, containing advertisements and the less important matter, is worked at leisure; and the second form, containing the leading article, important news, and other matter of consequence, is reserved until the last moment, and is then thrown off with immense rapidity. For the usual description of book-work, machines are constructed to work both forms. In these, perfect register and the exact and even distribution of the ink are of the greatest consequence, and such immense rapidity is not necessary. These machines, therefore, differ very much in construction, though not in principle, from those used for newspapers.

In Plate CCCCXV. will be found an engraving of Cowper's admirable perfecting machine, an explanation of which will comprehend a sufficient description of the single machine. Upon slides running the length of the frame which supports the whole machine, traverses a carriage which conveys the two forms of type, and attached to both ends of which are tables for the distribution of the ink. The reciprocating motion is given to this carriage by means of a pinion, which works alternately upon the upper and under surface of a rack. In gear with this carriage, and, supposing the paper to be omitted, in immediate contact with the type, revolve two cylinders of large dimensions, by which the impression is given; these cylinders are separated by the registering drums, but are kept in uniform and steady motion by two large wheels, the teeth of which work within each other. The ink is distributed over the forms by an apparatus attached to each end of the frame, consisting of a trough which contains the ink, in contact with the edge of which, or very nearly so, a metal roller called the *ductor* is made to revolve slowly by means of a catgut, which passes over a pulley attached to the axis of the impression-cylinder. A composition-roller is made to rise into contact with the ductor and receive a portion of ink, with which it descends, and thus communicates it to the inking-table as that passes underneath it at the extremity of the traverse. Two composition-rollers are placed somewhat diagonally across the frame, and their spindles being of extra length, as the table passes under them they are caused to revolve and also to travel slightly across it, thus evenly distributing the ink all over the surface of the inking-table, the cross motion removing any accidental accumulation of ink. The table now traverses under four other composition-rollers, supplying them with an even quantity of colour, which they in turn distribute over the type as it passes under them in going and returning, the form being thus rolled no less than eight times. These rollers are mere ly dropped into notches in the frame, their own weight sufficing to retain them in their places, and give the necessary impact upon the type. For the purpose of carrying the paper round the different cylinders there are two distinct series of endless tapes, one of which, coming in contact with the left surface of a small roller,[1] passes from thence to the right surface of the first cylinder, and underneath it; thence *over* the first and *under* the second drum; thence to the left surface of and under the second cylinder; from this it passes to the right, until it arrives at the roller first mentioned. The course of the second series of tapes is different; for, following the course of the first series, and in contact with it (supposing the paper withdrawn) until it has passed with it under the second cylinder, it then takes a different direction, and, turning to the left, passes over the machine until it arrives at the roller from which we have commenced the description. Both series of tapes are kept tightly stretched by means of various small rollers revolving in different parts of their course. The paper being laid upon other tapes from a table at the right of the machine, is moved forward until it comes in contact with the endless tapes, and being received between them, it is passed under the first cylinder, and the first side is then printed; thence passing over and under the drums on to the second cylinder, it receives the impression upon the other side; thence it passes onward to the point where the tapes take different directions, when it is shot out printed on both sides, upon a board between the cylinders and under the drums. The whole machine is put in motion by means of a strap which passes over a wheel under the frame, and *may* be worked by the power of men, but is mostly worked by steam. It is capable of doing very fair work at the rate of from 2000 to 2400 impressions, or 1000 or 1200 perfect sheets, per hour; it requires but two boys, one to lay on and one to take off the sheets.

The machine with which the Times is printed is also constructed by Messrs Applegarth and Cowper. It consists of four impression-cylinders, two of which are in contact with the types at the same moment; the other two rising in the meanwhile. There are consequently eight series of tapes, two for each cylinder. It requires four boys to lay on and four to take off, and the machine will give 4200 impressions within the hour. Its appearance, of course, differs very much from the machine before described.

The ingenuity of these gentlemen, especially of Mr Cowper, has been exerted in the invention of many mechanical improvements in printing. Several of his machines, upon various constructions, have been brought into use with considerable success. These, however, are the principal machines of his invention. They at first, it is believed, turned their attention to the fixing stereotype plates upon the periphery of the impression-cylinder, and brought the scheme into practice; but these are superseded by the simpler and more useful machines above described.

The machines of Mr Napier are in very general repute. They have the advantage of being easily worked by two men, thus saving the great expense and unavoidable dirt

[1] The description commences with that portion of the machine where the paper first enters the machinery, for *endless* tapes can of course have no *beginning;* the words *first*, *second*, and *third*, &c. must therefore be understood to refer to the position as respects the *right hand* of the reader.

Practical Printing. Printing Machines.

where a steam-engine is employed, with its necessary appliances, boilers, coals, &c. They stand in a very small compass, and do beautiful work. As far as regards motion and impression, they do not greatly vary from those previously described; but in the method of conveying the paper, obtaining register, and inking, they are altogether different. The paper is laid to a certain gauge, when in the revolution of the cylinder grippers are made to compress the edge of the paper upon it, very much in the manner in which the fore-finger closes on the thumb. It is by these means conveyed entirely round it, in the course of which the first impression is given. At the commencement of the second revolution these grippers open at the precise moment the grippers attached to the second cylinder close, and thus convey the sheet over the second form. Tapes pass under the second cylinder, *between* the blanket and the paper, and over a pulley upon a bar, by the mere friction of which the sheet is thrown out upon a board. These grippers are made to act with such perfect certainty that the best possible register is obtained. The inking apparatus consists of a trough with a ductor and vibrating roller, which communicates the ink to composition-rollers, by the revolution of which in contact with each other the ink is perfectly distributed, and from these to the type. A cross motion is communicated to the distributing roller by means of a worm in the elongated spindle. As but one impression is given during the traverse of the table in each direction, the cylinder which does not at the moment hold the paper would be in contact with the type, had not Mr Napier added a beautiful adjustment, whereby the cylinders rise and fall alternately, so that the one not in use passes over the form intact. This machine will work from 1000 to 1200 perfect sheets per hour, and requires but two boys. Mr Napier has constructed several other machines of great merit, one of which, for newspapers, will perfect 2000 sheets per hour by the labour of two men. Another with four cylinders, for rapid newspaper work, prints the Morning Chronicle newspaper at the rate of 6000 sheets on one side per hour. But the perfection of speed will be obtained by one for which he has lately taken out a patent, by which the extraordinary speed of 15,000 or 20,000 per hour will be obtained. The ordinary type is affixed to the periphery of a cylinder of enormous dimensions, in contact with which ten smaller impression-cylinders revolve, each with its inking and other apparatus so arranged that every revolution of the large cylinder works ten sheets of any size; and yet so steady and so silent is its motion, that there is no danger of any disruption of the type, even at that extraordinary rate. The types are held in their place by means of the rules, which are made considerably larger at the top than at the bottom, thus occupying the space which would be found in consequence of the types not being so formed as to radiate from the centre of the cylinder. Mr Napier is the inventor of many very ingenious improvements in the machinery of printing.

Mr Rowland Hill has brought into partial use a machine giving 10,000 impressions per hour; the types are slightly pyramidical, in order to radiate from the centre of the cylinder upon which they are fixed. These machines, however, are better adapted to printing stereotype plates, to which a curved form could be given, which is the principle of Nicholson's and other early machines.

A machine-press has long been at work in Mr Spottiswoode's office, in which the impression is given by a self-acting platten, tables, rollers, friskets, and tympans. It does beautiful work, at the rate of 600 or 700 impressions per hour.

A well-seeming press has also lately been imported from America, in which there is an admirable application of two friskets, which are made to run in and out and rise and fall alternately. The tympan is upon the platten. There appears, however, to be some practical defects in the working. Owing either to this or their high price, or prejudice, they have not been successfully introduced.

Practical Printing. Printing Machines.

These are by no means all the machines that have been devised, constructed, or brought into use. They are, however, all that it is necessary to mention, as the same principle is common to all. Every maker is at liberty to build them, with such modifications as his own talents may suggest.

The many-coloured excise stamps and cheques are printed by very complicated and ingenious machinery, the invention of the late Sir William Congreve. They are printed from steel or copper plates, the plate from which the dominant colour (as black) is transferred being cut away in those parts where the red appears, whilst the red plate has the parts which are to receive the ink in relief; the edges of the two plates being bevelled, the relievo of the red plate fits with exquisite nicety into the corresponding parts of the black plate; these being properly adjusted on the machinery, the red plate descends, and is then coloured by rollers, as is the black plate, which remains stationary; the red plate now rising, fits itself into the black plate, and the impression is instantly given, thus printing both colours at once, and with such excellent adjustment, that it is almost impossible, by the minutest examination of the print, to form any guess of the mode of execution. The apparatus for adjusting these plates has of course nothing in common with ordinary printing machines, and it differs materially from them in other respects: the table is stationary, the cylinder traverses over it, and the inking appliances follow it in its traverse.

Copperplate Printing.

Copperplate printing.

It has already been mentioned that the principle of printing from engravings on copper or steel is the very reverse of printing from types, inasmuch as the former are graven in intaglio and the latter in relief, and consequently the pigments are contained within the lines of the one, and the surface of the plate is free of all colouring matter, whilst the surface of the other is carefully covered with ink, and the depressions as carefully kept clean. It must be sufficiently obvious that these essential differences must require very different manipulations. Accordingly, the printing of such engravings has little in common with letter-press printing. The copperplate or roller press may be described as consisting of two upright cheeks, with ribs diverging at right angles. At a short distance above these ribs is a solid iron cylinder, which is made to revolve by means of a star, consisting of many radii, as long as the height from the ground will permit. Upon the ribs runs a carriage; under the carriage, but not attached to it, is a roller, which, by means of a lever, is made to rise, thus pressing the carriage with any degree of force against the upper cylinder. The copperplate is laid over a brazier of ignited charcoal, and when at a sufficient heat the workman takes a considerable quantity of ink upon a rubber of linen rag, and smears the whole face of the plate, working it carefully into every mark of the graver; the heat of the fire, at once expelling the air and thinning the ink, causes it to enter into the minutest strokes, so that the slightest scratch or corrosion in the copper presents itself upon the paper: a plate even not sufficiently polished, that presents no visible defects to the clearest eye, will cause the paper to appear dirty; so exact are the effects of this mode of printing. When the ink has been sufficiently rubbed in, the face of the plate is cleared of the superfluous ink with another linen rubber; the workman, then, with the balls of his hands, carefully cleanses the surface, drying his hands upon a lump of whitening, until the face is perfectly cleaned and polished. In this operation the skill of the workman is exhibited, for in thus cleansing the plate he must be most

Prints ‖ Priories.

careful not to rub out the ink from the gravures, and to leave colour proportioned to the depths of shadows required; for although the engraver may, indeed must, have defined every stroke, much depends upon the manner in which the printer does his part. It is not every man that has a rolling press that can produce first-rate prints. On the contrary, he must be himself no inconsiderable artist, and stands in a much higher relation to the engraver than the bellows-blower to the organist. The plate being ready for printing, is removed from the brazier to the carriage of the press; the paper, well damped, is laid upon it; a leather tympan is closed over it, the carriage run in a little, and the lever raised; the carriage, &c. being thus brought into close contact with the upper roller, the latter is made to revolve by turning the star; this causes the carriage and plate to run in, and thus an immense lineal impression is given to every part. The ink used in copperplate printing differs somewhat from that used by letter-press printers. It is of two kinds; one for fine ornamental work, one for common printing. For fine work, such as large and delicate engravings, the material used is the finest Frankfort black; it is ground on a stone with a muller, and mixed with weak burnt linseed oil, until it attains a consistency of thick paste; a little strong burnt oil is then added, and it is then ground up again, a drier to make the ink set firm on the paper being added. The drier is composed of small portions of litharge, white copperas, and sugar of lead; these should be well pounded with the muller before they are ground up with the oil and black. A small portion of the best Prussian blue may be added; but the greatest care must be taken that it be well triturated, as otherwise it is liable to make the best work smear. The blue must be ground up by itself with weak oil; to this driers are to be added. The whole compound is then to be ground up again, and added to the black: the mixture must be then ground upon the stone for about ten minutes, the palette-knife being freely used until all portions are thoroughly commingled. The ink for common work is prepared in the same manner, but without the Prussian blue; and the common English black is substituted for that of Frankfort.

Priscianus ‖ Prismoid.

Copper-plate presses, of a superior description, made chiefly of iron and brass, have lately been introduced, in which several excellent appliances are to be found to diminish the labour and improve the general quality of the work. The most important improvement would appear to consist in heating and inking the plates without removing them from the press, and distributing the ink over the surface and in great measure removing it by means of composition-rollers, the ultimate cleansing being left to manual skill as before. In copper-plate printing, however, so much depends upon the skill and care of the workman, that whatever improvement may be made in the mode of gaining pressure and other mechanical means, it does not appear probable that the present slow and careful progress will ever be superseded. (B. D.)

PRINTS, the impression taken from a copperplate engraved. See ENGRAVING.

PRIOR, in general, something before or nearer the beginning than another with which it is compared.

PRIOR more particularly denotes the superior of a convent of monks, or the next under the abbot.

Grand PRIOR is the superior of a large abbey, where several heads are required.

PRIOR, *Matthew*, an eminent English poet, was born at London in the year 1664. His father dying whilst he was very young, an uncle, a vintner, gave him some education at Westminster school, and then took him home to train him up to his own trade. However, at his leisure hours he prosecuted the study of the classics, particularly that of his favourite Horace. Through the influence of the Earl of Dorset he was sent to St John's College in Cambridge, where, in 1686, he took the degree of bachelor of arts, and afterwards became fellow of his college. In 1710, he was supposed to have had a share in writing the *Examiner*. In 1711, he was made one of the commissioners of the customs; and was sent as minister plenipotentiary to France, for negotiating a peace with that kingdom. Soon after the accession of George I. to the throne of England in 1714, he presented a memorial to the court of France, requiring the demolition of the canal and new works at Mardyke. The year following he was recalled; and upon his arrival was seized by a warrant from the House of Commons, and strictly examined by a committee of the privy council. Mr Robert Walpole moved the House of Commons for an impeachment against him; and Mr Prior was ordered into close custody. In 1717, he was excepted out of the act of grace; however, at the close of that year he was set at liberty. The remainder of his days he spent in tranquillity and retirement, and died in 1721.

PRIORIES, ALIEN, were cells of the religious houses in England which belonged to foreign monasteries. When manors or tithes were given to foreign convents, the monks, either to increase their own rule, or rather to have faithful stewards of their revenues, built a small convent here for the reception of such a number as they thought proper, and constituted priors over them. Within these cells there was the same distinction as in those priories which were cells subordinate to some great abbey. These alien priories were most of them founded by such as had foreign abbeys founded by themselves or by some of their family. The whole number is not exactly ascertained. Dugdale has given a list of a hundred, Weever of a hundred and ten.

PRISCIANUS, one of the most celebrated of the ancient grammarians, was surnamed Cæsariensis, either because he was born at Cæsarea, or had received his education there. He flourished in the reign of Justin (A. D. 518–527), and was a contemporary of the philosopher Boethius, and of Cassiodorus, the minister of Theodoric king of the Goths. He taught grammar at Constantinople, and received a salary from the court, which makes it probable that he was a Christian. Priscianus was distinguished for his thorough acquaintance with grammar, of which he has left us a proof, in a very complete work on that subject. It bears the title, *Commentariorum Grammaticorum libri xviii. ad Julianum;* or, in relation to its subject, *De Octo Partibus Orationis earundemque Constructione.* The first sixteen books are employed on an examination of the eight parts of speech of the ancients, and the last two on syntax in the proper sense of the word. We have also a poem of the same author, in hexameter verse, on the Emperor Anastasius, who died in the year 518; and the style and language are far purer than those of many others in the same age. We have also many other smaller works on grammar.

His grammatical works have been published by Krehl, Leipzig, 1819, in two vols.; and the smaller essays by Lindemann, Leyden, 1817.

PRISM, in *Geometry*, is a solid body, the two ends of which are any plane figures which are parallel, equal, and similar; and its sides, connecting those ends, are parallelograms.

PRISMOID is a solid body, somewhat resembling a prism, but its ends are any dissimilar parallel plane figures of the same number of sides, the upright sides being trapezoids. If the ends of the prismoid be bounded by dissimilar curves, it is sometimes called a *cylindroid*.

PRISONS.

Prisons. THE arrangements necessary to adapt prisons to the ends for which they are designed seem to require little more than the exercise of practical good sense; and yet the manner in which the practice of the world blunders on from one absurdity, and very often from one atrocity to another, shows pretty distinctly, how little the public affairs of mankind have hitherto had the benefit of that practical faculty, or of any thing that resembles it.

Ends of imprisonment. Prisons have been applied to three purposes: 1*st*, That of safe custody; 2*dly*, That of punishment; 3*dly*, That of reformation.

It is very evident, that each of these purposes requires an arrangement of means peculiar to itself.

Though each requires a combination of means peculiar to itself, it does not follow that, of the means required for each, a portion may not be the same in all. Every body will acknowledge that this is the case.

The means of safe custody, for instance, are equally required for those who are imprisoned in order to be punished, and those who are imprisoned in order that they may be reformed, as for those who are imprisoned to the sole end of being made present at a particular time and place.

The arrangements, then, for safe custody, form a basis, on which every combination of means for attaining any of the other ends of imprisonment must always be erected. Other means for the attainment of these ends are to be considered as accessions to those required for the first.

It is a corollary from this position, that the same house may, at one and the same time, be employed for all the three purposes. Those properties in the building which make it fittest, at the least expense, for safe custody, make it fittest also for the purposes either of punishment or of reformation. This will be rendered abundantly apparent in the sequel; and from the single circumstance, that the means of punishment and reformation are only additions to those of safe custody, it wants not much of its demonstration already. If the arrangements needed, for those who are to be punished, and those who are to be reformed, interfere not with one another, or with those needed on account of the persons in safe custody merely, the truth of the corollary is indisputable; for nobody will deny that, in point of economy, there must be very great advantage.

Means of safe custody. I. We shall consider, first of all, what is the best combination of means for safe custody. Dungeons and fetters are the expedient of a barbarous age. And in respect of prisons, as of every thing which comes within the precincts of law, the expedients of a barbarous age are, with great industry, retained in those which are civilized; they are, indeed, not only retained with great industry, but preserved with a success which, if it were not experienced, would be altogether incredible. As the expedients of a barbarous age are still preserved in many more of the arrangements for the purposes of law, so it is but of yesterday that the prisons of our forefathers have been regarded as fit for reform, or the means which in their ancestorial wisdom those sages devised for attaining the ends of imprisonment were supposed capable of being altered for the better, by their less instructed sons.

It is at last, however, allowed, that inspection is a means for safe custody, which renders unnecessary all but very ordinary means of any other description. Thus, so long as a man is, and knows that he is, under the eyes of persons able and willing to prevent him, there is very little danger of his making an attempt, which he sees would be vain, to effect a breach in the wall, or force open the door, of his cell. Any great strength, therefore, in such wall or door, as well as fetters upon any part of his body, the object of which is to make provision against such an attempt, are wholly unnecessary; since the attempts are sure of not being made, or being instantly frustrated. Prisons

The plan of a prison, in which the power of inspection is rendered so complete, that the prisoner may be, and cannot know but that he is, under the eyes of his keepers, every moment of his time, and which we owe to General Bentham, so univerally known for his mechanical genius, is described by his brother, in his work entitled *Panopticon, or Inspection House;* where also a system of management is delineated, and its principles are so perfectly expounded and proved, that they who proceed in this road, with the principle of utility before them, can do little else than travel in his steps.

An idea of the contrivance may be conveyed in a few words. It is a circular building, of the width of a cell, and of any height; carried round a space, which remains vacant in the middle. The cells are all open inwards, having an iron grating instead of a wall, and, of course, are visible in every part to an eye properly placed in the vacant space. A narrow tower rises in the middle of that space, called the inspection tower, which serves for the residence of the keepers, and in which, by means of windows and blinds, they can see without being seen; the cells, by lights properly disposed, being capable of being rendered as visible by night as by day.

We have thus provision for safe custody; and along with it, five other important purposes are gained. First of all, there is great economy; the vast expense of thick, impenetrable walls, being rendered unnecessary. Secondly, all pretence of subjecting prisoners to the torture and degradation of irons is taken away. Thirdly, no misbehaviour of the prisoners can elude observation, and instant correction. Fourthly, no negligence, or corruption, or cruelty, on the part of the subordinate agents in the prison, can escape the view of their principals. And, fifthly, no misconduct towards the prisoners, on the part of their principals, can remain unknown to the public, who may obtain a regulated admittance into the inspection tower, and regulated communication with the prisoners.

The persons who are liable to be in prison, for sure custody merely, are of three classes. First, persons apprehended, and about to be put on their trial, for the commission of a crime. Secondly, persons convicted of a crime, and about to receive their punishment; and, thirdly, debtors.

Under a good system of law, very little provision would need to be made for these cases. It is one of the essential properties of a good system of law to permit as little time as possible to intervene between the apprehension and trial, and between the conviction and punishment, of a person for a crime. There would never, therefore, be many such persons in any prison at a time. And under a good system of law, there never would be any body in a prision on ac-

Prisons. count of debt.[1] This is mentioned merely to show how little, under a good system of law, the apparatus and expense of a separate prison, for this set of cases, would be wanted.

These persons being inmates of a prison, for insuring their presence merely, the question is, What treatment they ought to receive?

Persons in prison before trial, and debtors, are persons of whom nothing is certainly known, but that they are unfortunate. They are, therefore, entitled to all the benevolence which is due to the unfortunate.

What is done for them in a prison must, however, be done at the expense of the community, that is, by sacrifices demanded of those who are not in prison; and those sacrifices ought, undoubtedly, to be the smallest possible. The question is, therefore, to be settled by a compromise between the principle of benevolence, and the principle of economy.

The principle of benevolence undoubtedly requires that the health of the prisoners should not be impaired; for this, importing the premature loss of life, is in reality the punishment of death, inflicted upon those to whom no punishment is due.

That health may not be impaired, three things are indispensable: 1st, a wholesome apartment; 2dly, a sufficiency of wholesome food; 3dly, sufficient clothing.

The principle of economy, with equal certainty, exacts, that all those should be of the cheapest possible kind.

All this is abundantly clear. It is equally clear that, with respect to those who are in prison for safe custody merely, the principle of benevolence requires, and the principle of economy does not forbid, that they should be free to use any indulgence, which costs nothing, or which they provide for themselves; and that no farther restraint should be placed upon their liberty than the custody of their persons, and the rule of economy, which prescribes the limits and accommodations of the place, may demand.

Few words will be necessary to show what is appropriate to the case of the man who is in prison during the interval between his sentence and his punishment.

By the supposition, in this case, his punishment is something distinct from his imprisonment; because, if not, it is a case which comes under another head, namely, that of persons who are in prison for the sake of punishment; and will be fully considered in another part of this discourse.

If he is in prison for detention merely, his punishment, as meted out and fixed by the judge, being something wholly separate; every particle of hardship imposed upon him, not necessary for his detention, is something without law, and contrary to law; is as much injustice and a crime, when inflicted upon him, as if inflicted upon any other member of the community. The same considerations, which, as we found above, ought to regulate the imprisonment of debtors, and persons in custody before trial, namely, the compromise between the principle of benevolence and the principle of economy, apply, without the smallest difference, to the case of persons who, during the interval between their sentence and its execution, are in prison for the mere purpose of preventing their escape.

We foresee a difficulty, or rather an objection, for there is really no difficulty in the case.

Persons come into prisons, who have been accustomed, in the preceding part of their lives, to all degrees of delicate and indulgent living; to whom, therefore, the hard fare prescribed by the principle of economy will occasion very different degrees of uneasiness.

Such persons, when in prison for safe custody merely (what is required when persons are in prison for punishment, or for reformation, will be seen hereafter), may be allowed to make use of any funds which they may possess for procuring to themselves all unexceptionable indulgencies. They may be also allowed the exercise of any lucrative art, consistent with the nature of the prison, for procuring to themselves the means of such indulgencies. This the principle of benevolence dictates, and there is nothing in the principle of economy which forbids it. Prisons.

We shall be told, however, that there are persons who have been accustomed to a delicate mode of living, and who come into prison without the command of any funds, or the knowledge of any art, by which they may soften the hardship of their lot; and we shall be asked what is the course which our philosophy recommends for the treatment of them? The course which it recommends is very clear. Such persons are paupers, and whatsoever treatment is fit for paupers of the description to which they belong, is fit also for them. If there are any funds, to which as paupers they can apply, the application should be open to them. If there are none, and there is no person to whose benevolence they can resort, the effects of such a destitute situation must be sustained, the same way in a prison, as they must be, when any person falls into it, out of a prison.

II. Having stated what appears to us necessary for illustrating the principles which ought to regulate the imprisonment of those, in respect to whom safe custody is the end in view, we come, in the next place, to the case of those, in respect to whom, in addition to safe custody, punishment is to be effected through the same medium. Means of punishment

This subject we shall unfortunately be under the necessity of treating superficially; because, in order to explain it fully, we ought to have before us the whole doctrine of punishment; and, for this purpose, a development, too extensive for the present purpose, would be required.

This we may assume as an indisputable principle; that whatever punishment is to be inflicted, should be determined by the judge, and by him alone; that it should be determined by its adaptation to the crime; and that it should not be competent to those to whom the execution of the sentence of the judge is entrusted, either to go beyond the line which he has drawn, or to fall short of it.

We have already established, on what seemed sufficient reasons, that for persons confined, on account of safe custody merely, the cheapest accommodation, not importing injury to health, in respect to apartment, food, and clothing, should alone be provided at the public expense.

Unless in the case of those whom the judge might condemn to lose a portion of their health, as the punishment due to them, by the sufferings of an unwholesome prison, unwholesome food, or improper clothing, this accommodation ought to be afforded even to those who are placed in prisons for the sake of punishment. And if it should be thought that the loss of health never can be a proper punishment, if it has never been regarded as such even by savages, and is repudiated by every principle of reason, then it follows, that the accommodations which we have described in the former part of this discourse, as required in the case of prisoners detained for safe custody, are required in the case of prisoners of every description.

This is a basis, therefore, upon which every thing is to rest. In every rational system of prison management, this is an essential condition. We are now to see in what manner, upon this footing, punishment, by means of imprisonment, is to be effected.

One mode is sufficiently obvious and sufficiently known. The punishment may be rendered more or less severe by

[1] If evident fraud were committed in contracting the debt, or if the property of others, obtained by loan, had evidently been dishonestly spent, or dishonestly risked, such fraud or dishonesty, being crimes, not a debt, might justly subject a man to imprisonment, or any other sort of due punishment.

Prisons. its duration. Want of liberty is, in almost all cases, a source of uneasiness; want of liberty, added to the denial of all pleasures of sense, can hardly ever fail to be a source of great uneasiness. A long imprisonment, therefore, with the cheapest accommodation not importing injury to health, must be a severe punishment. This, it is evident, may be graduated to more or less of severity, not only by degrees of time, but the use of such means as the prisoner might command for procuring accommodations and indulgencies.

To this imprisonment may be added solitude. But though we mention this, as a practicable addition to simple imprisonment, it is well known how little, unless for short periods, and on very particular occasions, it is to be recommended.

The modes which lately have been most in repute, of adding to the severity of simple imprisonment for the purpose of punishment, have been two; 1st, hard labour; and, 2dly, bad prisons, and bad management in those prisons.

1. The species of labour which appears to have obtained the preference is that of treading on a wheel.

If a criminal in a prison is ever to be let out again, and to mix in society, it is desirable that nothing should be done, and least of all done on purpose, to make him a worse member of society than when he went in. There cannot be a worse quality of a punishment, than that it has a tendency to corrupt and deteriorate the individual on whom it is inflicted; unless, indeed, he is a prisoner for life; in that case, people of a certain temper might say, that making worse his disposition is a matter of little importance; and to them we have no time to make any reply.

Most of those persons who come into prison as criminals, are bad, because they have hated labour, and have had recourse to other means than their industry of attaining the supply of their wants and the gratification of their desires. People of industry, people who love labour, seldom become the criminal inmates of a prison.

One thing, however, is pretty certain, that men seldom become in love with their punishments. If the grand cause of the crimes which have brought a man to punishment is his not having a love but hatred of labour; to make labour his punishment, is only to make him hate it the more. If the more a man hates labour, the more he is likely to act as a bad member of society; to punish a man with labour, and then to turn him out upon society, is a course of legislation which savours not of the highest wisdom.

Besides, in treating labour as an instrument of punishment, call it *hard* labour, if you will, what sort of a lesson do you teach to the industrious and laborious class, who form the great body of your people? to those whose lot is labour, whose lot is hard labour, harder than any which it is in your power to impose? What compulsory labour is so hard as many species of voluntary labour?

As an instrument of reformation, labour, as we shall presently see, is invaluable. As an instrument of punishment, hardly any thing can be conceived more exceptionable. That which is the source of all that mankind enjoy, that which is the foundation of every virtue in the most numerous class of the community, would you stamp with ignominy and dishonour, by inflicting it as a punishment upon the worst and basest of your people? Is this your expedient for rendering it, what every wise legislator would wish to render it, honourable, and thence desirable?

There are other objections, perfectly decisive, against labour as a punishment. It operates with more inequality than almost any other instrument of punishment that ever has been invented. The same degree of labour would kill one man, that to another would be only a pastime. From this source we may apprehend the most horrid abuses, in the continuance of those tread-mills. We may be very sure, that the most atrocious cruelty will often be inflicted upon those who, with strength below the average standard, are placed in those penal engines; while, in the case of those whose strength is much above that standard, they will hardly operate as a punishment at all. Prisons.

It is impossible that the judge can measure out this punishment; because the judge has not the means of ascertaining the relative strength of the parties who come before him. It must, therefore, be left to the jailor. The jailor, not the judge, will mete out and determine the degree of suffering which each individual is to undergo. The jailor, not the judge, is the man who adapts the punishment to the crime. Hence one of the stains which mark a careless and stupid legislation.

It is a far inferior, though still no inconsiderable proof of a blundering legislation, that the labour, if labour it must be, is not of such a sort as to be useful. The turning of a wheel, by human labour, when so many better means of turning it are possessed in abundance, is destitute of even this recommendation. It stands upon a similar footing with the contrivance of the jailor, whom Mr. Bentham celebrates: "We are told somewhere," he says, "towards the close of Sully's *Memoirs*, that for some time after the decease of that great and honest minister, certain high mounts were to be seen at no great distance from his house. These mounts were so many monuments of his charity. The poor in his neighbourhood happened to have industry to spare, and the best employment he could find for it was, to remove dirt from the place where it lay to another where it was of no use. By the mere force of innate genius, and without having ever put himself to school to learn the economy of a French minister, a plain English jailor, whom Howard met with, was seen practising this revived species of pyramid architecture in miniature. He had got a parcel of stones together at one end of his yard, and set the prisoners to bring them to the other; the task achieved, now, says he, you may fetch them back again. Being asked what was the object of this industry, his answer was, 'to plague the prisoners.'" In a note on this passage, Mr. Bentham says, "I beg the jailor's pardon; what is above was from memory; his contrivance was the setting them to saw wood with a blunt saw, made blunt on purpose. The removers of mounts were a committee of justices."

2. Bad prisons, and bad management in these prisons, is a mode of punishment, the recommendation of which has lately been revived, after we might have hoped that, in this country at least, it was exploded for ever. The language of such recommendation has, on several occasions, been heard in Parliament; and an article on Prison Discipline, which appeared in the *Edinburgh Review*, cannot be interpreted in any other sense. Even the Committee of the Society for the Improvement of Prison Discipline have not been able to withstand the force of what they may have supposed to be fashionable doctrine. In their *Fourth Report*, lately published, which we are sorry to say evinces more of good intention, than of enlightened views for its guidance, they say, "No charge can be more mistaken and unfounded, than that the plans recommended by this institution are calculated to introduce comfort into gaols. The committee are of opinion, and have always contended, that severe punishment must form the basis of an effective system of prison discipline;" thereby confounding two things, punishment, and prison discipline; which are totally distinct; and between which, it is of so much importance to preserve the distinction, that without it not a rational idea can be entertained about either.

No doubt crimes must be punished. Who needs instruction upon that head? But when the judge has prescribed, that, in a particular way, which he points out, a particular measure of pain shall be inflicted upon an individual; and when the individual is taken, and made to sustain the operations through which the pain is generated; what has this

Prisons. to do with the discipline of the prison? It is an act or series of acts, *sui generis;* acts not forming any part of the ordinary course of prison management; acts which would not have taken place, which ought not to have taken place, if the judge had not commanded them, and which were performed solely and exclusively in obedience to his commandment. This is the nature of punishment; other punishment than this there ought to be none.

The Committee would make severe punishment the basis of prison discipline. What business have the Committee with punishment? The assigning of punishment the legislature have given to other and fitter hands; to those who take cognizance of the offence, and alone ought to measure the punishment. Saying they would make punishment the basis of prison discipline, what do they intend by this ill-contrived expression? Do they mean, that their jailor shall hold the scales, and weigh out the proper quantity? If not, how are they to be understood; for if not the jailor but the judge is to weigh, and the jailor is to do nothing but punctually carry the prescription of the judge into execution, then is punishment, in no proper sense of the word, any part of prison discipline. It is a separate operation, performed on a particular occasion, because prescribed by the judge, and in the exact manner in which the judge has prescribed it. If it is, on the other hand, a part of prison discipline, then all the horrid consequences, inseparable from making the jailor the judge and meter of punishment, present themselves to the imagination; and he who can endure to look at them may dwell upon the picture of a prison, wherein the poor will not be more comfortable than at home, nor by the charms of imprisonment enticed to the commission of crimes.

Nothing can more clearly indicate that state of mind, which consists in confusion of ideas, than the vague language which we hear about the necessity of making prisons the seats of wretchedness, that crimes, they say, may not receive encouragement.

We have already seen, that, unless it is part of a man's punishment, expressly ordained, that he shall lose a portion of his health; that is, that his life shall be cut short; that is, that after a period of torture, he shall receive a capital punishment; a wholesome apartment, a sufficiency of wholesome food, proper clothing, all of the cheapest kind, must be provided for every body. When people talk about making prisons seats of wretchedness, do they mean something worse than this?

Many of them will no doubt answer, yes, we mean hard labour in addition. We ask again, do you mean hard labour, according to the prescription of the judge, or without the prescription of the judge? If according to the prescription of the judge, the case is the same with that which we have previously examined. This instrument of punishment is exceptionable, only because it is a bad instrument.

The whole matter evidently comes to this. If more wretchedness is desired than what is implied in confinement under the worst accommodation which the preservation of health admits, it must be meted out, either at the pleasure of the jailor, or the pleasure of the judge. The writer in the *Edinburgh Review*, and the Committee of the Society for the Improvement of Prison Discipline, speak as if they had never reflected upon the difference.

We do not mean to bestow a word upon that theory, which, for the prevention of offences, would make prisons scenes of wretchedness at the pleasure of the jailor.

The only question which can deserve a solution is, what mode of inflicting evil in a gaol can the judge make use of for best attaining the ends of punishment? The answer is not difficult. Unless, where that course of reformatory discipline, which we shall delineate under the next head, suffices; and we allow, that, though it may be made to involve no small degree of punishment, there are cases in which it would not suffice; it will certainly appear, that prisons are not the best instruments of punishment. Prisons.

A single consideration suffices for the proof of this proposition. Punishment in a prison loses the grand requisite of a punishment, that of engendering the greatest quantity of terror in others, by the smallest quantity of suffering in the victim. The principal, perhaps the sole end of punishment, is to restrain by the example; because, with respect to the individual whom you have got, if you think society in any danger from him, you can keep him in sight, and no more is required. Yet, the language we hear about the tread-mill, and hear from the mouths of high persons, implies, that hardly any thing more is in their minds, than the effect upon the individual sufferers. "Nothing finer than the tread-mill; a fellow who has been in the tread-mill never comes back again." Be it so; but by your leave, this is a very insignificant part of the question.

The choice of expedients, for obtaining the punishment best adapted to the several cases for which a course of reformatory discipline does not suffice, belongs to another head of inquiry, and must, for the present purpose, be regarded as determined. All that it is necessary for us to show here is, that a prison is not the proper scene for it, nor the instruments of a prison the proper instruments. To render a punishment the most efficacious in accomplishing the great end of punishment, it must be a punishment calculated to make the strongest impression upon the senses, and, through the senses, upon the imagination, of the public at large; more especially of that part of the public who lie under the strongest temptations to the commission of similar crimes. But the punishments inflicted in a prison are withdrawn from the senses of the public, and seem as if they were intended to make the smallest possible, not the greatest possible, impression upon the imaginations of those who are to be deterred from crime. They are defective, therefore, in the most essential quality of a punishment, and can always be supplied by better means of attaining the same end.

The proper idea of a prison is that of a place of custody, and that alone. This idea ought to be clearly, and distinctly, and steadily preserved in the mind, in all disquisitions respecting prison discipline. Punishment and reformatory discipline may be annexed to safe custody; and in as far as they consist of a series of operations, requiring time for their performance, it is essential to them. As reformatory discipline consists wholly in such a series, imprisonment is a necessary condition of it. Since many, also, of the best kinds of punishment are not such as can be executed all at once, but require a period of time, imprisonment is equally necessary for these punishments. But though you must have safe custody to enable you to execute certain punishments, and also to enable you to carry into effect a course of reformatory discipline, safe custody is not the same thing with punishment, nor the same thing with reformatory discipline; and no conclusions can be depended upon, in which ideas so distinct are confounded.

III. Having thus considered prisons, as instruments of safe custody, and as instruments of punishment; two of the purposes to which they have been applied as means; it remains that we consider them as instruments of reformatory discipline, the third of the purposes to which they have been applied. Reformatory discipline.

It is necessary, first of all, to state a clear idea of reformatory discipline.

When offences, against which it is necessary that society should have protection, are committed, it is desirable that the punishment of the offender should have three properties: 1*st*, That it should deter all other persons from committing a similar offence, which is its most important property. 2*dly*, That it should have the effect of deterring the man himself from a repetition of the offence. 3*dly*,

Prisons. That it should have the effect of removing his former bad habits, and planting useful habits in their stead. It is this last property which is sought to be communicated to his punishment by reformatory discipline.

As the creating and destroying of habits is the work of time, and as the restraint of safe custody, and restraint from all indulgencies, except under certain conditions, are necessary to reformatory discipline, whatever punishment is involved in such protracted coercion, is a necessary part of reformatory discipline.

What is desired is, to create a habit of doing useful acts, in order to break the habit of doing hurtful acts. To accomplish this, means must be obtained of making the individual in question perform certain acts, and abstain from the performance of certain other acts.

The means to be employed for producing performance cannot be of more than two sorts, the pleasurable and the painful. A man may be induced to perform certain acts, either by punishment or reward. He may be made to abstain from performing certain acts by an additional means, by withholding the power of performing them.

The latter is the means chiefly applicable for preventing the performance of hurtful acts in prisons; not only crimes, but acts of intemperance, gaming, or any others, the tendency of which is towards crime. As this is nearly the universal practice, the reasons of it must be so generally known, as not to need development.

The inquiry which chiefly calls for our attention is, what are the best means of producing the performance of those acts, the habit of performing which we desire to render so perfect, that it may be relied upon for the effect, even in a state of freedom?

The persons on whom reformatory discipline is intended to operate, belong to the class of those who depend upon their industry for their support. So nearly, at least, do they belong to this class exclusively, that the immaterial exceptions may, in this general inquiry, be omitted.

The necessary foundation, in the case of such persons, not only for all virtues, but for abstinence from crime, is the habit of performing some one of those series of acts, which are denominated lawful industry, and for which the performers obtain payment or reward.

Labour, therefore, in some of its useful branches, is to be regarded as the foundation of all reformatory discipline. But as the object of this discipline is to train the man to love, not to hate labour, we must not render the labour in such a case any part of his punishment. The labour must, for this important purpose, be a source of pleasure, not of pain.

The way in which labour becomes agreeable to men out of a prison, is the way in which it can be made agreeable to them in a prison; and there is no other. Advantages must accrue from the performing of it.

The way of attaching to it advantages the most intensely persuasive, in a reformatory prison or Penitentiary, is exceedingly obvious.

There it is easy to prevent the attaining of any pleasure, except through the medium of labour.

What is provided in the prison, according to the principles already explained, is lodging, food, and clothing, all of the very cheapest kind not producing injury to health. In the monotony of a prison, there is no one who will not intensely desire pleasure in addition to this.

In the sentence of a criminal, who is subjected to reformatory discipline, it may, and as often as the case requires, it ought, to be rendered a part, that he shall not be permitted to make any additions to this hard fare from any source belonging either to himself or others, except his labour; but that what he earns by his labour he may, in a certain way, lay out to procure to himself better food, or any other indulgence (certain hurtful ones excepted) which he may desire. Few cases, indeed, will be found in which this simple contrivance will not produce steadiness of application. Prisons.

We have now then attained what is of principal importance. For if we have got the inmates of a prison to labour steadily in some useful branch of industry, to look to labour as the great or only source of their enjoyments, and to form habits of so doing, sufficiently confirmed to be depended upon for governing their conduct in a state of freedom, we have prepared them for being useful members of society, and our purpose is accomplished.

Here, then, comes the question, By what arrangements, in detail, can the business of confining, maintaining, and setting offenders to work, be most advantageously performed?

In other words, in what hands should the government of penitentiaries be placed, and under what rules should it be ordained for them to act?

It is an universal axiom in morals, that no security is equally to be depended upon for any desirable result, as the interest of those upon whom its accomplishment depends. If, in devolving upon a man the task of bringing about a particular end, we make it his interest to bring it about in the best possible manner, especially if we make it his interest in any high degree, we can hardly be disappointed in counting upon his most strenuous exertions. On the other hand, if he has no interest, or a very inconsiderable interest, in the end which he is entrusted to bring about; if little cognizance will be taken of his proceedings, whether good or bad; if to attend to the business would be exceedingly troublesome, to neglect it will produce little inconvenience; we may be very sure that, by a great majority of men, the business of the task devolved upon them will be very imperfectly performed. If they can make a profit out of oppression, or if, as is the case, to so great a degree in prisons, they can consult their ease by imposing additional and mischievous restraints upon the prisoners, their interests are strongly set against their duties, and ill conduct is still more perfectly secured.

This last, how deplorable soever the confession, is the state of management of all British prisons, with hardly any exception. There is a jailor, who receives a salary and power, and is told to manage the prison well; and there is a number of justices, that is, gentlemen of the neighbourhood, who obtain not a little power, and a great deal of praise, for undertaking to do certain public duties of a local nature, with little interest in doing them well, and no little interest in doing them in many respects exceedingly ill, who have the charge of looking after him. Varieties we cannot afford to particularize. This is the general description.

The management, then, of the prison, is the joint concern of the jailor and the justices, or magistrates, including sheriffs, who, jointly or severally, have no such interest, as can be expected generally to produce any considerable effect, in any thing more than such a kind of management as will not excite attention and indignation by its badness. All the degrees of bad management, which are within those limits, having little or no interest to prevent, they have abundant interest to permit.

It is surely not necessary, that we should go far into the detail of this case, to show the causes which it places in operation, and their natural effects.

First of all, it is sufficiently evident, that the jailor has an interest in obtaining his salary, and other emoluments, with as little trouble to himself as possible.

It is not less evident, that the magistrates have an interest in getting the power and credit attached to their office with as little trouble to themselves as possible.

This is enough. The book of human nature is clear upon the subject. This principle, at uncontrolled work in

Prisons. a prison, is perfectly sufficient to generate all the evils which those abodes of misery can be made to contain.

It is undeniable, that so far as those, who thus have the superintendence of jailors, are disposed to consult their ease, and to perform negligently a troublesome duty, which they may perform well or ill, just as they please, so far they will be indisposed to listen to any complaints against the jailor. It saves them a good deal of trouble to confide in the jailor. They speedily come, therefore, to look upon confidence in the jailor, and to speak of it as a good thing, a duty. "Has not the jailor been most carefully and judiciously selected for his office, by wise and good men? (namely ourselves). Would it not be an injury to a man of his character to distrust him? And to distrust him, for what? For the complaints of prisoners. But prisoners are always complaining, always giving trouble. Jailors are a good set of men. Prisoners are a bad set of men; especially complaining prisoners. They are the very worst kind of men; they are, therefore, to be silenced; and it is often very difficult to silence them; nothing but harsh measures will do it; when harsh measures, however, are absolutely necesssary, it is the duty of jailors to use them, and the duty of magistrates to protect such men in the discharge of so important a duty."

Such are the feelings and conclusions which are undeniably prompted, by the mere love of ease, in the bosom of such men as English magistrates.

So far as the magistrates consult their ease (men generally do consult their ease when they have not a preponderating motive to the contrary), the jailor is at liberty to consult his ease.

In the jailor's consulting his ease, every thing that is horrid in a prison finds its producing cause.

What the jailor has chiefly to guard against is, the escape of his prisoners, because that is a result which cannot be hidden, and will not escape animadversion. But the love of ease prompts him to take the easiest means for this purpose; locking up in dungeons, loading with irons, and prohibiting communication from without; in other words, all the measures which are the most tormenting to the prisoner. If the prisoner, confiding in his ingenuity or his strength, makes any attempts to free himself from this misery, by escaping, the disturbance which is thus given to the ease of the jailor is a cause of pain, proportional to the love with which he cherishes his ease; this pain excites resentment, resentment calls for vengeance, and the prisoner is cruelly punished. The demon despotism reigns in his most terrific form.

This is only one half of the evil. The servants of the jailor, the turnkeys, as they are called, and others who wait upon the prisoners, are as fond of their ease as the jailor is of his. If the jailor has no adequate motives to make him take care that the business of the prison is well done, he will repose the same confidence in his servants, which the magistrates so liberally exercise towards him. He will leave them to indulge their ease, as he could not do otherwise without disturbing his own.

From the servants of the prison indulging their ease, neglect of the prisoners is the immediate and unavoidable consequence. From neglect of prisoners, that is, of men placed in a situation destitute of all the means of helping themselves, all those evils, which, in another situation, could be produced only by the most direful oppression, immediately ensue.

Upon the servants of a gaol, cherishing their ease, and left by their superintendents to do so, every call of a prisoner for help, from relief from any annoyance, is felt as an injury, and resented as such. Cruelty speedily comes, as a co-operator with neglect, to fill up the measure of the prisoner's calamity.

The prisoner, finding himself destitute of all remedy, except he can prevail upon the people who approach him to remove some of the causes of the misery which he endures, has recourse to bribery, when he can possibly command the means; and then pillage, without limit and without mercy, is added to all the evils of this den of horrors. Prisons.

If such are the consequences of entrusting the management of prisons to persons who have no interest, or not a sufficiency of interest, in good management, we have next to consider the important question, by what means a sufficiency of interest in good management can be created? We need not have any doubt, that if a sufficiency of good accrues to the managers from every particle of good management, and a sufficiency of evil from every particle of bad, we shall have as much as possible of the good, and as little as possible of the evil.

The grand object, as we have stated, of reformatory discipline is, to create habits of useful industry. A second object is, to preserve the health of the prisoners, and impose upon them no suffering, not implied in the conditions of their confinement, or prescribed by the judge. A third is, by moral and religious tuition, to generate and strengthen good dispositions. A fourth is, to attain those ends at the smallest possible expense.

It is not difficult to give the manager or keeper of a reformatory prison or penitentiary, a very strong interest in all these important results.

We have already seen, that the mode of giving to the prisoner a motive to labour, is, by giving him a share in the produce of his labour.

It is evident that an equally certain mode of giving to the jailor a motive for obtaining as much of that labour as possible, that is, for doing all that depends upon him to make the prisoners labour as much as possible, and as productively as possible, is by giving him also a share in the produce of their labour.

It may be said, however, that if the jailor receives a share of the labour of the prisoners, he will have a motive for making them labour too much: labour may be so excessive as to equal the severest torture.

Effectual expedients, however, for the prevention of this evil, are easy and obvious. In the first place, it does not seem necessary that the labour should be in any degree compulsory. If a prisoner is, according to the rule above laid down with respect to the cheapest fare, confined to the coarsest kind of bread, and water, if he does not labour, but has it in his power to add to his enjoyments by labouring, more especially if he may labour in company, but if he will not labour, must remain in solitude, the cases will be exceedingly few in which compulsion will be needful; and these might, if it were deemed of sufficient importance, be specially provided for by the legislature.

If a man may work, or not work, as he pleases, and much or little as he pleases, there is no need of any farther security against excessive labour. If there were, it would be afforded by the interest which it is easy to give to the jailor in the health of the prisoner.

Giving to the jailor a share in the produce of the labour of a prisoner has two happy effects; not only that of giving him an interest in rendering the value of that produce as great as possible, but that, also, of giving him an interest in the health of the prisoner, because the produce of a man's labour is greater when he is in health than when he is not.

This may be increased by giving to the jailor, through a very obvious channel, an interest, and an interest to any amount, in the life of each prisoner. It being ascertained what is the proportion of persons of a similar age that die annually, when not confined in a prison, all that is neces-

Prisons. sary is, to entitle the jailor to a sum of money for each of the individuals above that proportion whom he preserves alive, and to make him forfeit a sum for each individual above that proportion who dies. This sum, it is evident, may be sufficiently high, to ensure, on the part of the jailor, a strong desire for the life, and thence a proper attention to the health of the prisoners.

Another particular in this case requires attention. It is obvious, that the motive of the prisoner to render the quantity or value of his labour the greatest, is, when the share which he enjoys of it is the greatest. It is equally obvious, that the motive of the jailor to promote the augmentation of this quantity or value is the greatest when his share is the greatest.

If the whole of the produce of the labour of each of the prisoners were left to be divided between himself and the jailor, the motives of the two pa ties, taken jointly, would be at the highest. And the question then would be, according to what proportion should the division be made?

The peculiar circumstances of this case permit the most decisive answer to be returned. No evil can accrue, and every good purpose is best gained, by allowing the jailor to take as much as he pleases. It being first established that he can employ no compulsory methods, that the prisoner must have as much of the coarsest fare and accommodation as he needs, whether he works or not, and that work can thus be obtained from him only by the operation of reward, it will be the interest of the jailor to make his reward sufficiently high to obtain from him all the work which he can perform, and, in his situation as a criminal, he ought, generally speaking, to receive no more. The propriety of this regulation, therefore, rests on conclusive evidence.

Here, however, an objection worthy of attention occurs. If the jailor receives so great a proportion of the produce of the labour of the prisoners, he may receive a much higher remuneration than the nature of his duties requires; and so far the public is deprived of a fund which ought to be available for the public service.

This observation is true; and the question is, in what manner can the separation of what is necessary in remuneration of the jailor, and what should be detached for the benefit of the public, be most advantageously made?

If the situation of the jailor affords more than an adequate reward, he will be willing to give something annually in order to retain that situation. And for measuring exactly what he ought to give, there is a sure and well-tried expedient; it is, to lay the thing open to competition.

By this expedient, a double advantage is gained; for both the public receives as great a share of the produce of the labour of the prison, as is compatible with the due remuneration of the jailor; and the jailor being entitled, in the first instance, to share the whole of the produce with the labourers, having both to pay what he owes to the government, and obtain his own remuneration out of his share, has a motive as strong as if the whole were his own, to render the produce as great as possible.

It will easily be seen that this contract between the public and the jailor, if sufficient securities can be taken for its being cancelled, as soon as misconduct on his part should render it desirable that it should be so, ought, for important reasons, to be concluded for a considerable number of years, or for his life. It is of importance that those individuals, who are to undergo the reformatory discipline, and who are unacquainted with any trade, should, especially if they are young, be taught the trade in which their labours can be turned to the greatest account; and, to make it the interest of the jailor to have them taught, it is evident that he must have the prospect of enjoying the benefit of their skilled labour for a sufficient length of time. This short illustration we hope will suggest to the reader sufficient reflections for evidence on this point; and we must hasten to the remainder. Prisons.

We have now shown, to how great an extent, upon the plan which we have thus briefly sketched, the interest of the jailor is rendered coincident with the ends which are in view, and the most effectual of all securities is obtained for the goodness of his management. We proceed to show what additional securities this plan enables us to provide.

Let us, first of all, attend to the power of inspection, which may be afforded in a degree altogether unparalleled. By the admirable properties of the building which we have recommended, not only is the conduct of the prisoners rendered wholly transparent to the jailor, but the conduct of the jailor may be rendered equally transparent to his inspectors. And as the central lodge, or tower of inspection, may be entered by any number, without giving the least disturbance to the prisoners, without their even knowing that any body is there, the public may be admitted on such terms as to afford the full benefit of public inspection, the most efficient of all inspections, over the whole economy of the prison. By means of whispering tubes, oral communication might be permitted with the prisoners, at such times, and under such regulations, as would prevent it from interfering with the working hours, or other parts of the discipline, to all persons who might have a wish to hear if they had any complaints.

Another very simple expedient would make an important addition to the list of securities. It ought to be an obligation on the jailor to keep a book, in which all complaints of the prisoners should be entered, and, as often as they could write, signed with their names. Along with the complaint should be entered a statement of what had been done for removing the ground of the complaint, or of the reasons for doing nothing. And this book should be open to the perusal of the public, and should lie in a place convenient for the inspection of all the visitors of the prison.

A still more important and indispensable security would be, the obligation of the jailor to present, annually, to the principal court of justice, such as the Court of King's Bench in England, a report on the management and state of the prison during the preceding year, containing, with all other points of useful information, exact accounts of the receipts and disbursements; to verify these statements by his oath; to print and publish them at his own expense; and to answer, upon oath, all interrogatories made to him in open court by the judge, or by any other person, how much soever the answer might tend to his own crimination; and this as often as the judge might call upon him for such a purpose. By this means, with the obvious security afforded for other still more important ends, so perfect a knowledge would be communicated of the gains of the jailor, and the mode of obtaining them, as would ensure an accurate bargain, rigidly proportioned to the amount of them, as often as the contract came to be renewed.

The last thing which we think it necessary to recommend in the shape of a security, would operate as a test of the efficacy of the management in its character of a reformatory discipline. The jailor should be held bound to pay a certain sum, varying in proportion to the length of time during which the prisoner had been subject to his discipline, for each of the prisoners who, after liberation, should be convicted of a crime.

Connected with the important part of the subject relating to the labour of the prisoners, it is proper to bring to view the advantage of a subsidiary establishment for receiving and employing those who might be liberated from the prison. It is a well-known ground of lamentation, that persons liberated from a prison, find often great difficulty in obtaining employment, and are constrained, by a kind of necessity, to betake themselves to their former evil courses,

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though with the inclination to have devoted themselves to honest industry, had the means not been denied them. The best mode of obviating this great evil would be, to have a subsidiary establishment, the architectural form the same as that of the prison, in which the jailor should be obliged to receive all persons who have been liberated from the prison, and who make application for admittance; and to employ them on the same terms as the prisoners, with the single exception of its being in their power to remove when they please, and to make, in respect to terms all such stipulations with the jailor as may be for their mutual advantage.

The next part of the subject to which we proceed, is the plan according to which the prison shall be supplied with the articles which the prisoners are enabled by their labour to purchase.

As there are certain articles, such as intoxicating liquors, which ought to be altogether withheld, unless for special reasons permitted, and as the jailor could not have a sufficient command over the articles conveyed into the prison, unless he had in his own hands the power of supply; as the intercourse, also, which would be created with strangers, if the prisoners were at liberty to purchase of whom they pleased, would be incompatible with the discipline of the prison, the power of supplying articles of purchase to the prisoners ought to be confined to the jailor.

If it be objected that the jailor would thus have the power of oppressing the prisoners, by selling bad articles, or good articles too dear, the answer is, that he could not. We have already seen, that in order to derive from the prisoners the greatest quantity of profit to himself, he must give to them a reward for their labour sufficient to make them labour to the most profitable account. But if he sells articles to them at more than the usual price, this is merely a reduction of the reward left to them for their labour: this he cannot reduce beyond a certain point, without reducing the amount of his profit; and any greater reward than up to this point, the nature of the case renders undesirable.

We have now then stated all that seems necessary to be said on the three great subjects: 1*st*, of the structure and form of the prison; 2*dly*, the securities which may be applied for obtaining good conduct on the part of the jailor; and, 3*dly*, the first and principal part of reformatory discipline, namely, voluntary labour.

The remaining conditions of reformatory discipline will not require much explanation.

1. Separation, as far as concerns the sexes, and as far as concerns the good from the bad, is now so generally attended to as an object of importance, that the danger sometimes is of other things being too much overlooked in the comparison.

In a prison, such as we have described, in which, by means of moveable partitions, the cells may be enlarged or contracted at pleasure, and in which the prisoners are all under continual inspection, the power of separation, to any desired extent, is complete.

The two sexes, though inmates of the same prison, and simultaneously subject to the same inspection, may be as completely disjoined as if they were inhabitants of a different region. By a piece of canvass, and nothing more costly, extended in the form of a curtain, from the boundary on each side of the female cells, in the direction of a radius across the central area to the inspection lodge, the females would be as completely cut off from seeing, or being seen by the male prisoners, as if they were separated by seas and mountains; the same effect would be obtained as to hearing, by merely leaving a cell vacant between those of the males and females; and thus the space appropriated to each of the two sexes might, in the easiest manner, be diminished or enlarged, as their relative numbers might require.

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A much more complete and desirable separation than that which is aimed at, as the utmost in other prisons, is easily attainable in this. The ordinary separation of young offenders from old, of the greatly corrupted from those who are presumed to be less deeply infected, is still apt to leave associations too promiscuous and too numerous, not to be unfavourable to the progress of reformation.

The prisoners should be put together in companies of twos, and threes, and fours, seldom more; each company occupying a separate cell. It would be the interest of the jailor to put them together in such assortments as would be most conducive to the quantity and value of work they could perform, and to the goodness of their behaviour; that is, to the most perfect operation of the reformatory discipline; and his experience of their dispositions and faculties would of course fit him beyond any one else for making the selection.

It will have been all along understood, that, to attain the ends of inspection and economy, the same rooms or cells which form the day and working rooms on our plan, form also the sleeping rooms. Not the smallest inconvenience from confusion of things in the apartment can thence be derived; because the hammocks, which would be more convenient than beds, could be stowed away in little compass during the day.

It is also to be particularly observed, that whatever degree of seclusion might either be indulged to the feelings of an individual, or might be deemed conducive to his mental improvement, might still, upon this plan, be easily secured; because, by means of screens, a portion of the cell might be formed into as many private apartments as might be desired; and where experience of good conduct had laid a foundation for confidence, periods of seclusion, even from the eye of the inspector, might be allowed.

2. Nothing of great importance to be mentioned in this summary sketch seems now to remain, except schooling, and religious instruction.

The Sunday is the appropriate period of both. Sunday-schools are found by experience to be sufficient for communicating to children the important arts of reading, writing, and accounts. It would be obligatory on the jailor to afford the means of instruction in these respects to every prisoner who might not have attained them; together with all other means, not incompatible with the case, of promoting their moral and intellectual improvement.

3. The religious services proper to the day, and such other devotional exercises as might be thought requisite on other days, would be conducted by the chaplain, the prison affording remarkable facilities for bringing all the prisoners into a situation conveniently to hear; and also, which would be a circumstance of great importance, bringing the public from without, to participate in the religious services of the prison, for whom temporary accommodation in the vacant central area might be provided, and to whom, by the charms of eloquence and music, and the power of curiosity, it would be the interest of the jailor, by letting the seats, to provide sufficient attraction.

It seems to be necessary, before concluding, to obviate an objection, which, though it has seldom been urged as a reason against reformatory discipline, is yet considered as requiring a great deduction to be made in the estimate formed of its advantages. The objection is, that, by affording the means of employment to prisoners, we take away those means from a corresponding number of persons who are not prisoners, and thus sacrifice the deserving to the worthless.

This objection is drawn from some of the conclusions of Political Economy. That which affords the means of employment to labour is capital; in other words, the means of subsistence to the labourer, the tools he works with, and

Prisons. the raw material on which he is employed. When labourers are too numerous for the means of employment, it is evident that, if any new ones are added to the number, you can give employment to them only by taking it away from the old ones. It is, therefore, said, that by giving employment to prisoners, we make an equal number of honest workmen paupers.

In this objection, however, as is generally the case with false reasoning, a part only of the essental circumstances, not the whole, is taken into the account. In the first place, with regard to the prisoners, one principal part of the capital which puts labour in motion, namely, subsistence, is afforded to them of course, whether they labour or not.

In the next place, the objection proves too much; for, if it would be better, for the sake of affording employment to others, that the man should do nothing in prison, it would equally be better that he should have done nothing out of prison; better that we should have a portion of our population useless than productive. According to this doctrine, the proper rule, whenever population exceeds the demand for labour, and wages are low, would be to give subsistence to a portion of the people, on the condition of their abstaining from labour.

Thus much of the allegation is true, namely, that when to the subsistence, which you would have given at any rate, you add tools and raw materials, you so far diminish the quantity of tools and raw materials which can be furnished to others. But, counting only this circumstance, another most important circumstance is left out of the computation. This deduction of tools and raw materials is made once for all. The productive labourer replaces the capital, which employs him, with a profit. Advance to him, for one year, the food and other articles which he needs, you never need to advance any thing more. What he produces in the course of the year, replaces the food and all other articles which he has used, with a profit. But if he has not laboured, he has produced nothing; you have to supply him, therefore, with the means of subsistence, not one year, but every year, from the produce of other men's labour. If he labours, you have to give him once, out of the general stock of means for the employment of labour, subsistence for a year, with tools and raw material, and you have no occasion to give him any more. If he is to be idle, you give him, it is true, only subsistence, without tools and raw material, the first year; but you have to give him subsistence, that is, so far to diminish the means of employing other men's labour, every year; whereas, if he is a productive labourer, for the advance which you make to him the first year, he not only exempts you from all further deductions from the means of employing other men, but he every year adds to those means, by the whole amount of the profit made upon his labour. To make those persons, therefore, productive labourers, whom you must at any rate subsist, is to increase, not to diminish the means of employing others.

As to another objection which is sometimes offered, that the commodities produced in a prison glut the market, and injure other manufactures, this is still more evidently founded upon the consideration of part of the determining circumstance, without consideration of the remainder. If it is meant to apply not to one class, or two classes of commodities, but to the mass of commodities in general, it may instantly be seen to be untrue. The men who become sellers of the articles produced in a prison, become buyers to the same amount. Whenever a man sells a greater amount of articles than before, he gets the means of buying an equally greater amount. He always brings as much of a new demand into the market as he brings of a new supply. If he introduces more of some one commodity than the market requires, and reduces the profits on producing it, capital leaves that employment till the inequality is redressed. If the number of people is the same, and the quantity of commodities is increased, it is a contradiction in terms, not to say that the circumstances of such a people are improved. Prisons.

Having answered these objections, it does not occur to us that there is any thing more which in this outline it is necessary for us to add. The plan, both of construction and management, appears to us simple, and easy to be understood; and to offer securities for the attainment of the end, such as the imperfection of the human powers seldom permit to be realized. In the delineation presented, the only merit we have to claim is that (if our endeavour has been successful) of adding perspicuity to compactness. There is not, we believe, an idea which did not originate with Mr. Bentham, whose work ought to be the manual of all those who are concerned in this material department of public administration. (A.A.A)

Observations in continuation.

The preceding article has been preserved entire, as having been the offspring of a very powerful mind, and as presenting a perspicuous outline of the most advanced ideas of a good system of prison discipline, which prevailed up to the time of its publication, (April 1823.) Since that date, the art of managing prisons has made considerable progress, and experience has shewn more than one of the opinions above expressed to be erroneous. Some additional observations appear, therefore, to be requisite, in order to point out what has recently been done in this, and other countries, towards the advancement of this science; and what may be at present regarded as the leading objects to which all efforts for the perfection of prison discipline ought to be directed.

The public attention in England was first drawn to the evils of the existing prisons, towards the end of the last century, by the benevolent Howard; and the question of the establishment of a penitentiary system forced itself at the same time upon the consideration of the government, as a substitute for transportation, on account of the loss of the British North American Colonies, previously used for that purpose. Mr. Bentham's plan of the *Panopticon* was put forth at this juncture; but although the government seems to have had serious intentions of making some experiment of the kind, and more than one act of parliament for the erection of penitentiary houses was passed, no result followed, beyond the subsequent establishment of the penitentiary at Milbank for a certain number of convicts; a measure of too limited and partial a character to have any effect as a penal instrument, and, as it has turned out, equally worthless as a model for other prisons. The foundation, and gradual extension, of the penal colonies in New South Wales, provided an outlet for a large portion of the criminal population, and, in so far, diminished the urgency of the demand for penitentiaries; whilst the ordinary prisons continued to be managed with little thought or care, and without legislative interference. Even the review, by Sir Samuel Romilly's committee, in 1812, of the whole subject of secondary punishments, did not produce any improvement in the then existing system; and thus matters stood at the period when the preceding article appeared.

The gaol acts of 1823 and 1824,[1] which are now in force, and for which the country is indebted to the labours of Mr. Fowell Buxton and the London Prison Discipline Society, effected important changes in the administration of English prisons, especially those of the counties. They prescribed numerous regulations, amongst which the separation of the

[1] 4th Geo. IV. cap. 64, and 5th Geo. IV. cap. 85.

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sexes, the classification of all prisoners, and the enforcement of instruction, were prominent. But the benefits anticipated from them have, from various causes, been only partially realized; and their method of classification, which is founded principally upon technical distinctions, has, in particular, proved a signal failure.

American penitentiaries.

The select committee on secondary punishments, of 1832, in recommending the introduction of a modified system of solitary confinement, in imitation of that practised in some American prisons, shewed its participation in the opinion then beginning to prevail, of the merits of the penitentiary system of the United States. Many travellers spoke of them in high terms, and the French government had intrusted a mission of inspection to MM. de Beaumont and de Tocqueville, whose report, published in 1833,[1] has been highly appreciated throughout Europe. The distinguishing characteristic of this work is its philosophic impartiality. It describes with fidelity the two systems, both based upon the principle of isolation, but executing it, the one by means of separation, the other by silence, which pass respectively under the names of the *Philadelphia* and the *Auburn* system of discipline. The authors come to no very definite conclusion upon the relative merits of the two systems. That of Philadelphia had only just been put into action at the time of their visit, and they had not therefore those opportunities of extensive inquiry into its working which have been afforded to more recent observers. Mr. Crawford, the commissioner despatched by the British government in 1833, bears strong testimony, in his report,[2] to the superiority of the Philadelphia system; and the mass of valuable information which he collected, leaves no very favourable impression of the penitentiaries managed on the Auburn plan. Dr. Julius, charged more recently with a similar mission from the Prussian government, declared himself, on his return in 1836, favourable to the Philadelphia system;[3] and a still later report of MM. de Metz and Blouet, made to the French government in 1837, and to which we shall more particularly advert, recommends the same system more decidedly than any of its precursors.[4] The balance of the testimony of official inquirers preponderates strongly against the Auburn discipline.

Prisons of England.

The Lords' committee of 1835[5] collected a mass of evidence exhibiting the condition of the prisons of England and Wales, and reported to the house a series of resolutions suggesting reformatory measures. Amongst these is one thus recommending the silent system: "That entire separation, except during the hours of labour, and of religious worship, and instruction, is absolutely necessary; and that silence be enforced so as to prevent all communication between prisoners, both before and after trial." This resolution, however, did not receive any express sanction from the legislature; but in 1835,[6] an act was passed, whereby the power of establishing rules for prisons was transferred from the judges to the Secretary of State, and the appointment of inspectors was authorised. These inspectors have regularly made their official reports, which have been laid before Parliament, and to which the reader is referred for a complete description of the existing prisons of Great Britain. Whilst we write, (1838) a bill for the better ordering of prisons in England and Wales, is before Parliament. This bill is a step towards the introduction of the separate system, in as far as it will enlarge the powers of the Secretary of State to substitute separation for classification, and will suppress several minor abuses which have hitherto prevailed.

Prisons. Of Scotland.

The gaol acts quoted do not extend to Scotland, and the prisons in that part of the kingdom have continued, upon the whole, in a more defective state than in England. The greater part of the Scottish gaols belong to the royal burghs, whose funds being inadequate for their support, the construction and discipline have accordingly been neglected. The bad condition of these prisons is described in the report of the select committee of the House of Commons in 1826, which suggested the erection of proper places of confinement for large districts, with various other reforms. The many existing evils have since been particularized by the inspector for Scotland in his reports; and as a remedy for these, as well as for the more equal distribution of the burthen of maintaining the national prisons amongst all classes of the community, a bill has been introduced by the government during the present session (1838) for the improvement of the Scottish prisons. Under this bill, the liabilities of the royal burghs, and all other peculiar burthens, will cease; and all the expenses connected with prisons will be defrayed out of one common fund, to be raised by a general rate upon property. Suitable prisons are to be provided, under the direction of a general board, sitting in Edinburgh, to whom the sole authority and responsibility relating to all the prisons of Scotland is to be committed, subject to the controul of the Secretary of State, and of Parliament. A central authority of this nature may be the means of introducing important ameliorations into the present defective management; may materially aid the administration of justice; and may not only equalize, but greatly reduce, the cost to the community.

Of Ireland.

The prisons of Ireland are regulated by an act[7] which was framed on the basis of the English gaol acts. This law invests the Irish government with the power of appointing inspectors-general, who make annual reports; and the grand jury of each county and city are also required to appoint a board of superintendence, and a local inspector, whose duty it is to visit the prisons at least twice in every week. These measures have operated beneficially, the gaols having previously been in a most deplorable condition, and being now improved, particularly as regards the employment and instruction of prisoners. But the small prisons belonging to the local jurisdictions are stated to be still extremely defective.

Of France

If the progress of improvement in prisons has been slow in the United Kingdom, the system of management on the continent is, almost everywhere, still more defective. In France, the administration of penal justice previous to the Revolution, was altogether barbarous, consisting principally of capital and corporal punishments. But when something like a system began to be acted upon by the legislature of the Republic, a classification both of places of punishment, and of their inmates, began to be established. The French prisons are divided into the *bagnes*, for offenders sentenced to hard labour either for life or for a term of years; the *maisons centrales*, for those sentenced to long terms of imprisonment, exceeding one year; and the *maisons departementales*, for minor offenders sentenced to terms under one year. These establishments are for convicted prisoners; in addition to which, the law requires that there should be in every *arrondissement*, near to the *tribunal de première instance*, a *maison d'arrêt* for the detention of persons arrested, and also near to every assize court a *maison de justice* for the custody of those against whom a warrant of caption has issued from the court. There are be-

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[1] *Du Système Penitentiare aux Etats-Unis, et de son Application en France; suivis d'un appendice sur les colonies penales, et de notes statistiques.* Par MM. G. de Beaumont, et A. de Tocqueville, avocats à la cour Royale de Paris. Paris, 1833.

[2] Report of William Crawford, Esq., *on the Penitentiaries of the United States, addressed to H. M. Principal Secretary of State for the Home Department. Ordered by the House of Commons to be printed.* August, 1834.

[3] *Lettre addressée à M. W. Crawford, Inspecteur-Général des prisons de la Grande-Brétagne.* Par le Docteur Julius. Leipzig, 1837.

[4] *Rapports à M. Le Comte de Montalivet, pair de France, Ministre, &c., de l'Intérieur, sur les Penitenciers des Etats-Unis.* Par M. De Metz, conseiller à la Cour Royale et par M. Abel Blouet, architecte du gouvernement. Paris, imprim. royale, 1837.

[5] See the five Reports of this Committee, Session 1835.

[6] 5th and 6th Will. IV. cap. 38.

[7] 7th Geo. IV. cap. 74.

Prisons. sides the *maisons de dépôt*, or police stations, for the temporary custody of persons apprehended. These divisions, however, appear to answer little or no moral end, since the association of prisoners in every description of French prison is permitted, with scarcely any restriction, and the result is commonly a frightful degree of disorder, immorality, and mutual corruption.[1] The obligation of labour seems to be attended with little good effect; nor is there perhaps any position less favourable to reformation, than confinement in a French prison. These evils have recently excited much interest in the public mind in France, and the government has announced its intention to propose a general law for the separate confinement of the untried, though nothing seems to have yet been accomplished. Opinions are much divided in regard to the adoption of the system of silence or of cellular separation,[2] but the effect produced by MM. de Metz and Blouet's Report, has already led to a resolution in its favour, as regards the untried, by the council-general of the department of the Seine, who have recently voted a sum of three millions of francs for the construction of a prison for all the untried prisoners of Paris, upon the separate system.

Of Belgium

The prisons of Belgium were, soon after the Revolution of 1830, divided into three classses, analogous to those of France, viz. prisons for punishment; for safe custody *(maisons d'arrêt et de justice;)* and police stations, *(maisons de dépôt et de passage.)* Several improvements, especially the separation of the sexes, have been effected since that period; but the classification is, in other respects, very imperfect. The convicted of all ages and descriptions, are described as living together in vicious association, and sleeping in large numbers in the same dormitory. Imprisonment is any thing but reformatory, or even deterring, but is represented as a security against want, and an encouragement to improvidence, to such an extent, that admission to the *maison centrale* is hailed with joy by the convict. A plentiful diet, a weekly allowance of money, with liberty to expend it in beer, tobacco, coffee, and other indulgences, easy labour, and the society of friends, are described as removing even the semblance of penality; and the separation of the sexes, has under such circumstances, operated rather perniciously, by leading to more shameful vices. The inspector-general is thoroughly convinced of the necessity of introducing a system of cellular separation, and a new wing has been added for the purpose to the *maison de force* at Ghent.[3] The government is stated also to have in contemplation the erection of a prison on the separate system, at Liege.

Of Holland.

In Holland, there are distinct prisons for the accused, and for the convicted; and there are separate buildings for the confinement of women, and of juvenile offenders. The convict prisons are divided into those analogous to the *maisons centrales*, for offenders of the graver class, and houses of correction for minor offenders sentenced to terms under twelve months. A council of regents is attached to every prison, and reports to the central administration. The Dutch prisons are liable to all the objections attaching to systems of association, and nothing appears to have yet been effected in those of Switzerland towards separation. Prisons.

Of Switzerland.

The penitentiaries of Switzerland have acquired a high reputation, and deserve considerable study. Those of Lausanne and Geneva have carried the discipline of silence to a considerable degree of perfection, without the aid of corporal punishment; and the attention paid to the moral instruction of the prisoner is greater than in any of the penitentiaries of the United States. Lausanne is the best, and its situation, affording a view from the cell-windows, of the Lake of Geneva and the Alps, is not a little calculated to heal and elevate the mind of the penitent convict. But in neither of these establishments is communication between the prisoners effectually prevented, and they are consequently not free from the evil of mutual contamination. The penitentiary of Berne admits of more association, especially at night, than the two others mentioned, and can therefore scarcely be cited as a model of the silent system; but, looking at the whole management of the penitentiaries of Lausanne and Geneva, particularly the former, we believe that the moral reform of the prisoner may be anticipated with more confidence in these establishments than in any other prison conducted on the principle of association in silence, either in Europe or America. The small prisons, in other parts of Switzerland, are as bad as in the adjoining countries.[4]

Of Germany.

The prisons of Germany are principally known to us by the descriptions of Dr. Julius.[5] But our present space must confine us to the remark, that the last fifty years have materially ameliorated the prisoner's condition in point of health, cleanliness, and exemption from the tortures and fetters of the middle ages; and that little remains of absolute inhumanity in the treatment of offenders in any part of Germany. The bastinado is used, though not cruelly, as a disciplinary punishment in Austria, Prussia, and other states. The enforcement of silence, as well as the treadmill, have been introduced into some few prisons; but there is little classification worthy of the name, and the general system of management may be described as permitting the association, and consequent mutual corruption, of the prisoners. No prison has yet been established, on the plan of cellular separation, in any part of Germany, and the state of opinion amongst distinguished thinkers there seems at present but little in its favour. Professor Mittermaier of Heidelberg has declared himself opposed to it,[6] and we are not aware of any recent publicist there, except Dr. Julius, who is decidedly favourable to its adoption.

At Warsaw

A prison on the separate system was completed at Warsaw in 1835, capable of receiving 380 prisoners, and is in operation with good effect.

Of Norway

The Norwegian government is understood to contemplate the reform of its prisons, having lately dispatched a mission to England to acquire information on the subject.

Of less civilized states.

We have adverted to the prisons of the most civilized European states. There remains unfortunately to be drawn a revolting picture of the places of confinement in which humanity suffers, in countries the governments of which are less

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[1] See particularly the works of M. Moreau Christophe, the present inspector-general of the prisons of France, entitled *De l'Etat actuel des Prisons en France*, Paris, 1837; and *De la Reforme des Prisons en France*, Paris, 1838.

[2] See in favour of the silent system, *De la Reforme des Prisons, ou de la Théorie de l'Emprisonment, de ses Principes, de ses Moyens, et de ses Conditions Practiques;* Par M. Charles Lucas, tome i. Paris, 1836. tomes 2 and 3, Paris, 1838. *Des Moyens propres à Généraliser en France le Système Penitentiaire* Par M. Berenger. Paris, imprim. royale. 1836. *Rapport à M. le Ministre Secretaire d'Etat au Departement de l'Intérieur sur la Reforme des Prisons en France.* Par M. Gasparin; 6 Septembre 1836. In favour of separation, see particularly M. Moreau Christophe's works, and the Report of MM. De Metz and Blouet, before cited.

[3] See *Des Progrèset de l'Etat actuel de la Réforme Penitentiaire*, par Ed. Ducpetiaux, inspecteur général des Prisons, &c. de Belgique. Bruxelles, 1838, vol 2, No 9; a work full of valuable information, on the prisons and philanthropic institutions of Belgium, and several other countries.

[4] See *Mémoire sur le Systéme Penitentiaire addressé a M. le Ministre de l'Interieur en France.* Par M Aubanel, directeur du penitencier de Genève: Geneve, 1837; also several publications of MM. Cramer-Audeoud, Tallandier, &c. on the Swiss penitentiaries, and the opinions of M. Lucas and M. Ducpètiaux, in the works above cited.

[5] *Leçons sur les Prisons*, par le Dr. N. H. Julius, traduits de l'Allemand par H. Lagarmitte; Paris 1831.

[6] See an article by this eminent jurist in the *Revue Etrangére et Francaise de Législation;* Paris, Nov. 1836.

advanced beyond ignorance and barbarism. In such countries, a prison is in fact a place in which the strong wreak their vengeance upon the weak; the prisoner is not *punished;* he is subjected to certain physical and moral evils, from which neither himself nor society derive any benefit. Such injuries will continue to be inflicted until the influence of the moral sciences, especially that of jurisprudence, shall have pointed out the errors and blunders which are entailing so much misery upon mankind. It is not in Turkey, nor in Spain alone, that the slow progress of social improvement is to be lamented. It is a humiliating reflection, that the principal gaol in the British metropolis has for many years past been in as disgraceful a state as any in Spain. A comparison of the description of Newgate[1] with that of the Saladero at Madrid, makes it difficult to determine in which prison the evils of indiscriminate association and total laxity of discipline have led to the worst results. It is vain to anticipate from the exertions of philanthropy a remedy for such abuses. The reform of prisons is only to be hoped for by the uniform application of principles the soundness of which has been verified by an extended experience, and which reason has demonstrated as the best means of accomplishing the end for which punishment is inflicted. If it were otherwise, the government of prisons would be dependent upon the caprice of individuals, and consequently a ready instrument of oppression and injustice.

Principles of prison construction.

We proceed now to state the general principles which ought to be observed in the construction and arrangement of prisons,[2] and what are, in our judgment, the essential requisites of a good system of prison discipline.

The situation of a prison should be healthy, open, and calculated to secure a free circulation of good air. It is objectionable for a prison to be surrounded with buildings of any description; for which reason, a detached or isolated position ought, as far as may be, to be selected. Attention is also requisite to proximity to the courts and offices of justice, so as to facilitate the removal of prisoners before or after trial. The airiness of the situation is the more desirable, as there must be an extensive subdivision of the internal parts, to provide for the confinement of each prisoner in a separate cell. The site should be dry, and free from the effects of marshy damp soils. It should also be elevated, in order to avoid fogs, and the possibility of inundation; and the buildings should be so arranged as not to be exposed to view from any adjacent grounds.

The ground appropriated should be enclosed with a strong boundary wall, of sufficient height to prevent escapes. The buildings occupied by the prisoners must not adjoin the boundary wall, but a wide open space be preserved round the interior. A single gateway, or opening in the boundary, should form the only entrance to the prison, to be placed in front, and opposite the central building. At the entrance, and outside the boundary wall, may be placed the residences of the keeper and chaplain, so that the families of those officers may be unconnected with the prison.

Except for very small prisons, the radiating plan is preferable to any other, because the various objects of inspection, facility of access, convenience, and security, cannot be obtained so completely in any multiplied form of building, as in that which diverges from a central point of observation. In this respect, the principle of Mr. Bentham's Panopticon is followed, except in as far as it aims at viewing the interior of the prisoners' cells; the practicability of which, so as to exclude the possibility of the prisoner's retiring to a part of the cell where he cannot be seen, is very doubtful. With a system of separation, however, no central observation of the prisoners whilst in their cells need be attempted. The inspection required is of the corridors, and of the general establishment, exclusive of the cells.

In arranging the buildings, the grand requisite is the provision of a sufficient number of cells for the individual separation of each offender by day and by night. The construction of the cells should be such as to preclude all communication between the prisoners, and at the same time combine adequate space and means of ventilation, to ensure their health and admit of continued employment. The general dimensions of the cells should therefore be not less than thirteen feet by seven feet, and ten feet high, so as to contain about 1000 cubical feet. The cells may be ranged upon each side of, and opening into, the corridors running longitudinally through the radiating buildings. Every endeavour should be used to prevent the possibility of communication between the cells; to ensure which object, the partition walls should not be less than eighteen inches in thickness, and worked with close joints, so as to preclude, as far as may be, the transmission of sound. The requisite machinery should be applied to the introduction of warm air, and to the ventilation of the cells;[3] and each cell should be fitted with such necessary conveniencies, that the prisoner will never, under ordinary circumstances, have occasion to leave his cell, as well as with a bell, or equivalent instrument, to notify his wants. The cells on the upper stories may be arranged like those below; and if at the end of each radiating building two or three cells be laid together into a larger apartment, it may be used by the sick, and there will be no need of a distinct building for an hospital or infirmary. Airing yards should be provided for such prisoners as may, in the opinion of the surgeon, require exercise in the open air, and for the especial use of the untried.

In large prisons, one or more of the radiating buildings should be appropriated exclusively to the female prisoners.

If there be a chapel, it should adjoin the central building, and have several distinct entrances for the prisoners. Individual separation may be maintained during divine service, by placing each prisoner in a distinct stall, or sitting within the view of the officers, and of the chaplain. The form of the chapel will be that of an amphitheatre, with rows of seats rising above each other in face of the chaplain.[4]

Reception rooms must be provided near the entrance, in which prisoners may be placed on admission, before their examination by the surgeon, as well as suitable cleansing rooms and baths. Some peculiar cells will be required for the purpose of punishing offences against the discipline of the prison, and for offenders sentenced to short periods of solitude. The kitchen and other offices for the service of the prison need not be particularly described.

The use of any ornament or embellishment, whether external or internal, in a prison, seems entirely misplaced. The style of architecture should be plain, and divested of anything not conducive to the purpose of the building. A custom has prevailed of fixing chains, or axes, on the external walls, and of inscribing admonitory sentences over the gates, the good taste of which is very questionable. The mere name of the prison appears the most appropriate inscription.

Plates CCCCXVI. and CCCCXVII. exhibit plans of the ground and first floors of a prison, on the construction recommended, which are equally applicable to the confinement of the untried and the convicted. The imprisonment of debtors in general is inadmissible at all under a good system of law, as

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[1] See *Edinburgh Review*, No. 130, art. 3.

[2] For details of the most approved modes of prison construction, with numerous plans, the reader is referred to the *Second and Third Reports of the Inspectors of Prisons*, (Home District), presented to both Houses of Parliament, sessions 1837 and 1838. The plans referred to in this article are derived from these reports.

[3] See plans minutely describing the mode of ventilation, annexed to the Inspector's Report, Session 1837.

[4] See plan of a chapel annexed to ditto.

Prisons. unjust in principle, and mischievous in operation; but if there are some few cases of debtors deserving incarceration, there can be no impropriety in placing them in separate cells of the same description as are provided for other prisoners.

Discipline. Assuming, then, that we have a prison adapted to the discipline intended, we come to describe what the treatment of the prisoner should be, in respect of separation, employment, instruction, diet, and the care of health, and disposal after discharge. In considering these points, we shall distinguish the case of the untried, detained for safe custody only, from that of the convicted, who are confined either for correction, or for both correction and reform.

Separation. 1*st. Separation.* Mr. Bentham rejected absolute solitude from the administration of the Panopticon, as productive of despair and injurious to health, unless used for a few days only, for the purpose of repentance. He therefore proposed the classification of the prisoners into small companies in the discretion of the gaoler, which suggestion the writer of the preceding article has adopted as a part of his reformatory discipline. Now, there is no doubt that the confinement of an individual for any lengthened period in a cell, such as those in the ordinary English county gaols, would be very prejudicial to his health. These cells have been constructed merely for dormitories, not for habitation by night and by day. They are too small to enable the prisoner to take exercise, are badly lighted, imperfectly ventilated, in no degree warmed, and destitute of those conveniencies which are indispensable to render them fit and salubrious for constant habitation. But it is not in such cold, contracted, and desolate cells, that the introduction of the separate system is recommended. Nor is absolute solitude by any means intended. We are as averse from it as Mr. Bentham could possibly be. For it should be expressly understood, that the seclusion of the prisoner is to be relieved by stated daily visits, by manual occupations, and by his possessing the means of communication at any time with the officers of the prison. We entirely concur upon this important point with the inspectors of prisons for the home district, whose explanation we here subjoin, to prevent any misconception of the nature of the confinement intended.[1]

"In the case of the untried, the prisoner is placed in an apartment at least ten feet square, and ten feet high, sufficiently large to enable him to take exercise. This apartment is well lighted, ventilated, and warmed; water is laid in; a water-closet is provided; and in the fitting up, every arrangement is adopted essential to the prisoners' health. To this apartment the prisoner is strictly confined by day and by night; nor is he allowed to leave it at any time, except for the purpose of attending divine worship in the chapel. This seclusion, however, is broken by daily and stated visits of the governor, chaplain, surgeon, and other prison-officers. The prisoner enjoys the privilege of seeing his friends; he has every facility for consulting his legal adviser; he may send and receive letters; he is permitted to have unobjectionable books; he may receive suitable articles of food; he has the option of any employment that can be conveniently furnished to him; he is exempted from all discipline that is calculated to create irritation; he is tempted to commit no violation of prison-rules, and he is thus spared the infliction of prison-punishments; he is exposed to no quarrels; he is protected from those ruffianly assaults committed in every other kind of prison, which arise from the tyranny of the strong over the weak; his mind cannot be tainted and demoralized by relations of the burglar, nor his ears assailed by the language of the blasphemous and obscene." . . . . .

"The *convicted* prisoner, according to this system, is confined by day and by night, in such an apartment as has been described. Whatever is necessary for the preservation of his health is strictly attended to, but no indulgence in any shape whatever is extended to him. The distinctions observed in the treatment of the untried and convicted, are broad and definite. It has been seen that, under this system, the untried are permitted to receive visits from their connexions; the convicted are prohibited from such intercourse; the untried may also communicate with their friends by letter, the convicted have no such privilege; the untried are allowed to receive food beyond the prison diet; the convicted are rigorously restricted to the prescribed ration; with the untried employment is optional; upon the convicted a daily task is imposed." Prisons.

The inspectors, in their latest report, further state,[2]—"To guard against evils which might possibly arise from prisoners being confined in cells not fit for separate confinement, we recommend that the following provisions should form part of any law which may be framed for this purpose:—

"1st, That no cell be made for the separate confinement of a prisoner which does not contain at least 750 cubic feet, and is not lighted, warmed, ventilated, and fitted up in such a manner as is consistent with the health of the prisoner, and furnished with the means of enabling him to communicate at any time with the officers of the prison; and that no cell be used until its fitness be certified by the secretary of state."

"2d, That every prisoner shall be visited once at least every day by the governor, chaplain, and surgeon, in addition to other visits; and that every prisoner shall have the means of taking air and exercise as recommended by the surgeon, and shall be furnished with the means of moral and religious instruction, and with suitable books, to be selected by the chaplain, and also with labour and employment, unless specially withheld by order of the secretary of state."

Such, then, is the explanation of the system of separate confinement which has recently been recommended by the secretary of state to the English magistrates for adoption in all new prisons.[3] It is not, we repeat, a discipline of continuous solitude, but consists in the effectual separation of the prisoners *from each other*. It precludes their intercourse only with those whom it is for their moral good that they should not see. It rescues the untried prisoner, who may be innocent, from the shame of future recognition by gaol associates; it facilitates the correction of the convict sentenced to a short term of imprisonment; and affords the best possible opportunity of effecting the reformation of him whose confinement is sufficiently long to admit of the application of penitentiary discipline. The separate system is eminently calculated to favour the influence of Christianity on the depraved heart;[4] it has all the improving qualities of monasticism, without the entire renouncement of connexion with the world; nor is the rigour of its discipline at all comparable to that which many pious anchorets have voluntarily inflicted on themselves for the expiation of crime, or to the ordinary regime of the Grande Chartreuse, or the convent of La Trappe. Not that imprisonment should be regarded as a merely religious instrument, or visionary hopes indulged in of making criminals more virtuous than other men. It is unreasonable to expect more in general than to bring them into those habits which characterise the useful members of society. But there is little chance of attaining this object, unless the criminal be reduced to that docile and subdued frame of mind, which fits him to receive moral instruction, and to reflect upon his former errors. The acquirement of such a frame of mind, in the midst of associates, even of a carefully selected class of associates, as suggested by Mr. Bentham, we regard as im-

[1] Second Report, Session 1837.
[2] *Third Report* (Home District) Session 1838.
[3] See Lord John Russell's Official Circular, 15th August 1838.
[4] See Thomas a Kempis, *De Imitatione, &c* chap. 20, on the Love of Solitude and Silence.

Prisons.

possible. "Converse as much as may be," says Thomas a Kempis, "with God and thy own conscience. It is a good reflection which the philosopher made of himself, that he never was in other men's company, but he came out of it less a man than he went in; and this is what we may frequently confirm by our own experience."

The apprehension of danger to the mental or bodily health of the prisoner is unquestionably one not to be treated lightly. But there is no proof of any such result, in those prisons where the discipline of separation has hitherto been established. It has been in operation in the Glasgow Bridewell for about fourteen years; and the prisoner is never permitted to enter the open air, but is allowed exercise in a corridor, the cells not being quite so large, as we have stated to be requisite for ventilation and exercise.[1] Prisoners are not unfrequently confined here for periods of a twelvemonth and upwards; but their health has not been found to sustain any injury, and the moral effect of the imprisonment has been very favourable.[2] But it is the celebrated Eastern Penitentiary of Philadelphia that affords the strongest proofs, that individual separation can be enforced for lengthened periods with perfect safety to the body and mind. In this penitentiary, the prisoners are confined day and night in large airy cells,[3] and are cut off from all intercourse with their fellow-prisoners, whilst they are visited by the director and officers, the religious ministers, the medical attendants, the inspectors, and numerous official visitors, including the members of Congress, the judges, &c. There are prisoners in this penitentiary who have been there for years, without the slightest injury to their constitutions, and there are numerous instances in which health has been improved. In the seven years from the opening of the penitentiary in 1829 to December 1836, the average mortality did not exceed three per cent., (that at Sing-Sing being four per cent., and at Auburn two per cent.;) and of 697 prisoners during that period, the state of 312 who left the prison was as follows:[4]

78	in better health.
166	in equal health.
17	weaker, not worse.
13	in worse health.
4	much worse.
34	dead, including one suicide.
312	

Our limits do not admit of the details of the discipline of this establishment, but we have pointed out the works where the reader will find them. Suffice it to add that its success has been so far encouraging, that a second penitentiary has recently been built on the same plan at Pittsburgh, in the same State of Pensylvania, and that in the States of New Jersey, Rhode Island, and Missouri, penitentiaries on the separate system have also been lately erected. The principle of separation, as applied to prisons, is no doubt comparatively new; but it is not too much to say, that experience, as far as it has gone, has served to confirm the opinion of its excellence, to which reflection upon the theory of punishment, and the nature of the human mind, would be likely to lead the inquirer.

The basis of the silent system, like that of the separate, is isolation. It aims at solitude of the minds, whilst it permits the bodily association of the prisoners. The silent system ought to consist of the cellular separation of each prisoner by night, and of labour in common, with rigorous silence during the day. It is contended that the prisoner is thus morally isolated as effectually as if he were in a separate cell, and that the associated labour being more conformable to the habits of men in society than seclusion, the probability of converting the criminal into a useful citizen is proportionally greater. The system has been brought to a high degree of efficacy in the state-prisons of Auburn, Sing-Sing, Wethersfield, Charlestown, Baltimore, and Washington, in the United States, and in the houses of correction at Wakefield and Coldbathfields in England. But its strict enforcement involves several serious evils, not the least of which is the necessity of inflicting very numerous and vexatious punishments upon the prisoners. Every detected violation of the rules must be visited with some penalty, so that not only is the imprisonment contemplated by the sentence seriously aggravated; but the notion of an offence against prison discipline is insensibly confounded with one against law. In some of the American penitentiaries, corporal punishment has been used to a brutal degree; but even where this is not the case, the penalties are of an objectionable nature, such as the reduction of food, or confinement in dark ill-ventilated cells, both which have a tendency to impair the prisoner's health. In the year 1836, the number of punishments inflicted *daily* at Coldbathfields was computed at seventy-six, or about eight and-a-half per cent. on the number of prisoners, and no less than 6794 punishments, or about twelve per diem, were inflicted in that year for talking and swearing alone.[5] Referring to the two English prisons in which the silent system is most strictly carried into execution, it appears there were in the course of last year in

	Prisoners.	Punishments.
Coldbathfields House of Correction	9,750	13,812
Wakefield House of Correction	3,438	12,445
	13,188	26,257
In all the prisons in England and Wales.....	109,495	54,825

So that whilst these two prisons contain rather less than one-eighth of the whole number of prisoners, there were inflicted within them nearly one-half the whole number of punishments.[6] A feeling of perpetual irritation is thus kept up, the reverse of that tranquil and submissive frame of mind from which alone there is any chance of reformation. Nor can the system be maintained at all without so much vigilance, that a necessity has generally arisen of employing a number of the prisoners themselves as wardsmen and monitors, a practice wholly inconsistent with the punishment to which such prisoners have been sentenced, and subversive of discipline in many ways. The silent system, therefore, even when most strictly enforced, is open to many objections which do not attach to that of cellular separation, besides affording opportunities of communication which cannot exist where the prisoners are physically separated by the walls of their cells. But where the discipline of silence is loosely enforced, which is by far the most frequently the case in prisons where it is nominally established, it then becomes in fact a system of association, and open to all the evils of contamination, so baneful to the novice in crime, so pernicious in their effect upon society. Nor should it be disregarded that the observance of silence is enforced to no inconsiderable extent upon the untried, who are therefore subjected to the infliction of

[1] The dimensions of the cells are, for males nine feet by seven feet, and ten feet high; for females eight and a half feet by seven and a half, and seven feet three inches high.

[2] See the *Reports of the Inspector of Prisons for Scotland.*

[3] This prison contains eight corridors, and 262 cells. In three of the corridors, the cells are eleven feet nine inches long, by seven feet six inches wide, and in the other five corridors they are three feet longer. The cells on the ground floor have generally airing yards; but the prisoners in the upper cells are never allowed to enter the open air.

[4] We quote from the latest authority, MM. de Metz and Blouet's Report.

[5] Inspector's *Second Report*, (Home District,) 1837.

[6] Inspector's *Third Report*, (Home District,) 1838.

Prisons. punishment, contrary, if not to law, at all events to the first principles of justice.

There are, in fact, but three known systems of discipline; those of separation, of silence, and of association. We have described the first two; of the last, we shall only say, that it is the fruitful source of vice and demoralization, and that the prisons in which it prevails, are schools not of reformation, but of crime. Even the partial association allowed by Mr. Bentham is, in our view, wholly inadmissible. Classification will not cure the evil. Whether committed entirely to the discretion of the gaoler, or prescribed according to technical distinctions, as in the English gaol acts, classification will never prove an adequate remedy for the evils to be averted. The prisoner must be removed from the possibility even of *recognition* by another prisoner, before he can have a chance of acquiring that self-respect which, in a right sense, is indispensable to his moral reform.

A question may occur, whether the separation of the prisoner should be left, in any case, to his own option? The answer seems clear, that he should not. The convict has of course no right to choose what the nature of his punishment shall be. The untried, who is detained for safe custody, has no right to require to be provided with associates. He is injured, if his health is impaired, or if any needless restriction is placed upon him, but he is no more entitled to insist that other offenders committed to the same prison shall be confined in the same apartment with him, than to ask for a prisoner to be removed for the purpose from another gaol. If the state has a right to prescribe the place of his detention at all, it has also the right to debar him during such detention from the society of those at whose hands he would probably sustain the injury of moral corruption.

Employment. 2*d. Employment.* Assuming cellular separation to be the best system of confinement, the most proper mode of employing the prisoners will be that which is the best suited to the single cell. That hard labour, either in association or in solitude, should constitute the *gravamen* of the prisoner's punishment, is highly objectionable. Experience has shewn how great a mistake it is to use as a punishment for the basest of the people, that labour which should be held in honour, as being the only solid foundation of public prosperity and virtue. The evils anticipated in the preceding article from the tread-wheel, have been fully realized. It is a punishment which is characterized by a remarkable amount of inequality, and consequent injustice, in its operation. Not only is it necessarily unequal, because applied to persons of different degrees of physical strength, but in some persons it is carried to an excessive point of severity, whilst in others it is a merely nominal punishment. There is so little uniformity of system, as regards the number of hours devoted to labour, the height of the steps of the wheel, the rapidity of its rotation, and the proportion of prisoners placed upon it, that the severity of the punishment varies in almost every prison. The following county houses of correction, fortuitously selected, will illustrate this:[1]

Houses of Correction.	Average number of working hours per diem.	Height of each step.	Ordinary velocity of wheels per minute.	Ordinary proportion of prisoners off the wheel, to total number employed.	Average number of feet in ascent per diem.
Walsingham,	7	8 inches	36steps	$\frac{5}{7}$	7,799
Northampton,	$6\frac{1}{2}$	7 do.	48 do.	$\frac{1}{2}$	10,920
Coldbathfields,	$7\frac{1}{4}$	8 do.	48 do.	$\frac{1}{2}$	16,800
Petworth,	$8\frac{1}{2}$	9 do.	48 do.	$\frac{1}{2}$	18,473
Knutsford,	$8\frac{3}{4}$	$8\frac{3}{4}$ do.	48 do.	$\frac{1}{3}$	21,000

So that a prisoner sentenced to hard labour in the house of correction at Knutsford, would perform twice as much labour as at Northampton, and three times as much as at Walsingham house of correction. Nor is this all; for the severity of the labour depends also upon the season of the year in which the offender may be sentenced. In Maidstone gaol, for instance, in January, the number of working hours at the wheel is $6\frac{1}{4}$, and the number of feet of daily ascent, 12,000; whereas in the month of June, the working hours are $9\frac{1}{2}$, and the feet of ascent, 18,240; so that a man sentenced to two or three months hard labour in the summer, undergoes one-third more of the tread-wheel, than he who is committed in the winter, and that without any difference of diet. Such inconsistencies form a most serious objection to the system of tread-wheel labour, which, in connection with a more or less rigorous discipline of silence, is generally adopted in our houses of correction.

There can be no great difficulty in selecting suitable employments for the solitary cell. At the Glasgow bridewell a variety of works are carried on in the cells, from oakum picking, to the difficult art of print-cutting, with a view to suit the demand for labour in the surrounding districts, and to raise a fund applicable to the expences of the prison. At Philadelphia, the trades are principally weaving, tailoring, and shoemaking, and the two latter are the chief occupations at Millbank. The hand-crank is an instrument used in many prisons as a means of labour to the prisoner kept in temporary solitude.

The principles to be regarded in the employment of prison labour, are briefly these. The labour of the *untried* should not only be perfectly voluntary, but they are entitled to pursue any occupation not inconsistent with the good order of the prison, and of course to receive the whole of the profits which such occupation may yield. Upon the *convicted*, the state has the right to impose labour, although it may be questionable whether in general it is expedient to enforce it against the will of the prisoner. Under a system of separation there would be little occasion to impose a task, because experience has shewn that the prisoner in solitude very soon begins to desire labour as a boon; and this is precisely the disposition with which he ought to regard it. The convict should therefore be supplied with work at his own request; but it does not follow that he is entitled to any part of his earnings, because being no longer a free agent, the produce of his labour is the property of the State. That a convict should derive profit from his degraded situation is manifestly an abuse; except in so far, that where the term of imprisonment is long, the principle of reward, if discreetly applied, may occasionally prove a valuable instrument of reformation. Some discretion to present the penitent prisoner with a portion of his earnings might therefore be committed to the proper authority.

The notion of allowing the keeper, or any officer of the prison to participate in the profits of the prisoners' labour appears to us wholly erroneous. In Mr. Bentham's Panopticon, it is proposed to deliver over the prisoners to a contractor, to whom an interest in their earnings is given, in order to secure his training them in industrious habits. But the reason does not apply to prisons managed according to certain regulations prescribed by law, and governed by officers who are public servants, and responsible for their conduct to competent authority. There are no sufficient grounds for delegating to a contractor, that which is the business and duty of the government; nor should the officers of a prison look to any remuneration beyond their adequate salaries, nor have any contingent interest depending upon the manner in which the prisoners are employed.

The prisoners' earnings may be properly applied towards the expences of the establishment, and in some prisons they have become so productive, as to reduce the cost of mainten-

[1] See *Digest of Gaol Returns*, No. 6, in Appendix to Second Report of Inspectors of Prisons, 1837.

Prisons. ance to a mere trifle. It is quite possible that prisons may thus be made self-supporting, and be carried on without any public charge. Let it not, however, be supposed that the fact of economical management is at all conclusive of the excellence of a prison. The object of imprisonment is not production, but the correction and reform of offenders; and unless the employment be made subservient to these great ends, there will be little gain to the community, however cheaply this or that prison may be maintained. There is so strong a feeling, both in this country and the United States, in favour of stimulating production by prisoners, that some danger really appears to exist, lest higher objects should be lost sight of, and it should be forgotten that nothing is more costly to society than crime, and that in their tendency to the prevention of crime consists the only true economy of penal establishments.

It is hardly necessary to observe that the employment of prisoners as wardsmen, monitors, cleaners, cooks, or any other offices of trust, or menial services in the prison, is incompatible with a system of separation. The monitorial system has arisen chiefly out of the difficulty of enforcing the discipline of silence; but the practice of employing prisoners in domestic services is an abuse which prevails to a very great extent, and is a striking instance in which purposes of economy have been made to defeat the ends of justice.

Instruction 3*d*. *Instruction* is an important element of penitentiary discipline; but its effect must depend materially upon the length of the term of the prisoner's sentence. The late Lords' Committee recommended, that where there are fifty prisoners, there shall invariably be a chaplain whose whole time shall be devoted to his duties, and also a schoolmaster, not being one of the prisoners. In very short terms of imprisonment, little benefit can be anticipated from the labours of either chaplain or schoolmaster, and it is scarcely worth while to attempt the elementary teaching of reading and writing. But in every case, religious advice and exhortation should be imparted, and the chaplain, or an adequate number of chaplains, should devote a considerable portion of time to private converse with the prisoners, individually, in their cells. The judicious conversation of an intelligent clergyman on moral and religious subjects, and his friendly advice on such topics as may occur, are eminently calculated to raise the prisoner in the scale of morality, and to fix good resolutions in his mind. We need hardly remark, that if the chaplain is not what he ought to be, if he is a man of a weak, narrow, or ill-informed mind, or not thoroughly imbued with a Christian spirit, his labour will be in vain. But there are no bounds to the benignant influence of religion, rightly understood, in turning the wicked man's heart, nor can any vocation be more signally Christian, than that which consists in promoting the criminal's repentance.

We have referred to the plan of a chapel, according to which each prisoner may be separated during divine service. But a question naturally suggests itself, why, if separation is to be maintained, so as to preclude communion of worship, there is any occasion for a chapel at all? Divine service may be performed by a chaplain placed in the corridor, within the hearing of the prisoners, so that the prisoners are as much present at the service as if they were in the building called the chapel. This is the mode in which prayers are read at the Eastern Penitentiary of Philadelphia; and the seclusion of the cell is therefore not broken for the purpose of repairing to chapel. Whichever mode of celebrating divine service may be preferred, it is pretty certain that the private converse of the chaplain with the prisoner will always be the most beneficial part of his ministry.

As it seldom happens that all the inmates of a prison are of the same religious denomination, it will often be requisite to provide ministers of different religions, or sects, according to circumstances. Thus, although in England the majority of prisoners will in general belong to the Established Church, yet, where the number of Catholics, or of dissenters of any one sect in the prison, reaches a given point, it is clear that the services of a Catholic priest, or dissenting minister of such sect, ought to be secured and paid for by the state. For if it be concluded that religious instruction in indispensable to the reformation of the prisoner, it follows that such instruction can only be effectual when based upon the religion which the prisoner believes to be true. The circumstance, moreover, of the prisoner being deprived of his liberty, distinguishes his claim, in this respect, from that of other members of the community.

Prisons.

4. *Diet and care of health.* The loss of health forming no part of the prisoner's sentence, it follows that all due care must be taken of its preservation; and attention is therefore requisite to diet, clothing, cleanliness, and every other matter whereby it is liable to be affected. In some prisons the diet is so excessive as to be greatly superior to the ordinary fare of the free labourer, and consequently to constitute a *bonus* upon imprisonment; in others it is so inadequate as to impair the prisoners' constitutions, and reduce their physical strength. The latter appears particularly to be the case in those houses of correction where tread-wheel labour is enforced as a part of the silent system. The want of uniformity in the dietary of British prisons will seem very striking when the returns are referred to.[1] Under a system of separation, the sufficiency of the diet will easily be determined by the observation of the medical attendant, who will best regulate the variations of food which particular cases will require. The convict will, of course, be limited to the prison fare; the untried will, as at present, be permitted to receive such articles of food as his means may procure him. Stimulating liquors are only admissible within a prison for medical purposes, nor ought any canteen, or place for the sale of any food or liquors be permitted to exist within its walls.

Diet, &c.

It is not necessary to offer particular suggestions in regard to washing, clothing, and the other requisites of bodily health. The exercise of ordinary good sense will regulate such matters without difficulty. The utmost cleanliness should pervade every part of the prison. This is a point in which the English prisons surpass by far those of the continent. Nor need any apprehensions be entertained lest perfect cleanliness should make a prison too luxurious an abode. Cleanliness is no superfluous luxury; but should rather be regarded as having a strong tendency to purify the moral as well as the physical man.

5th. The disposal of the prisoner after his discharge is, at present, the most embarrassing question to which imprisonment gives rise. The short terms to which offenders are for the most part sentenced, make it quite visionary to anticipate reform as a general result of the best system; and even if the prisoner should have become a better man, the difficulty of his finding employment is (except in newly settled countries, like the United States) so great as to tempt him forcibly to relapse into crime. Several modes of provision for this difficulty were suggested by Mr. Bentham, such as, employment in the army or navy; encouragement of voluntary emigration to the colonies; the requiring security for good behaviour, with liberty to the surety to contract for the prisoner's labour; or a subsidiary establishment for the reception of the prisoners as a modified kind of imprisonment. Much has been done in France and elsewhere on the continent, by societies "*pour le patronage des libérés*," whose endeavour it is to place discharged prisoners in useful occupations. The British colonies, where labour is in very great demand, offer favour-

Disposal after discharge.

[1] See Appendix, No. 4. to Inspector's *Second Report*, Session 1837.

Pristina || Privy-Council.

able prospects to the emigrant; and if some systematic plan were organized, the opportunity of emigration would, without doubt, be joyfully accepted by many liberated convicts. To the young offender, such an opportunity is especially desirable. But compulsory banishment cannot be resorted to for the mass of offenders. It is therefore worthy of consideration, whether the convict should not, on his liberation, be placed under the temporary control of the police, in order that the police might be duly cognizant of his residence and occupation, and thus exercise a check upon his return to criminal pursuits? (See article Pólice). It might also be advantageous, in many cases, to commute sentences of imprisonment, either in the whole, or in part, for police surveillance, and thus to relieve the prisons of a mass of petty offenders, upon whom incarceration can rarely, even under the best system, operate beneficially. These, however, are questions belonging rather to the theory of punishment, than to the subject of prison discipline; nor is it possible to treat the latter subject at all satisfactorily, unless in connexion with an entire system of secondary punishments.

Our space has limited us to the leading points of prison management, nor is it requisite that we should enter into the details of minor arrangements. In every prison much will depend upon the good sense and discernment of the keeper, and the efficiency of the inferior officers, whose duties should be prescribed with precision, and enforced with exactness. The prison should be inspected, at frequent and uncertain times, by inspectors duly authorised to inquire into every thing in and relating to it. Proper books must be kept for recording every matter of importance, in a uniform manner, which the government should prescribe for all prisons, and the fewer and simpler the books the better. Uniformity of regulations should exist, as far as possible, in all prisons used for the same purpose, which can only be effected by a central authority charged with their superintendence. Prize.

The costs of constructing prisons do not fall within the scope of the present article. It may be useful, however, to refer the reader to M. Blouet's report before quoted. That architect estimates the cost of erecting a prison in Paris, for 480 offenders, on the Auburn, or silent system, at about L.80 per cell; and on the Philadelphia, or separate system, at L.148 per cell. The first cost of establishing the separate system will unquestionably be the highest; but, as it requires a smaller number of officers, and on other accounts, it may probably prove in the end the most economical. At all events, we repeat, it is not the *cheapest*, but the *best* system, that is desirable. Nor can we imagine a more legitimate appropriation of public money, than that which is expended with a reasonable prospect of preventing crime, by introducing into prisons efficient means of correction and reform.

(x.)

PRISTINA, a city of Turkey in Europe, in the province of Beldschterin. It is strongly fortified, is the seat of a Greek archbishop, and the principal market of an extensive district. It contains 2000 houses and 10,000 inhabitants; and is the centre of one of the greatest mining ports of Turkey, abounding in iron ore, and yielding some silver.

PRITTELWELL, a town of the county of Essex, in the hundred of Rochford. It is situated about one mile from the north bank of the Thames, near Southend. The population amounted in 1821 to 1922, and in 1831 to 2266.

PRIVAS, an arrondissement in the department of the Ardèche, in France, extending over 710 square miles. It comprehends ten cantons, divided into 107 communes, and 90,640 inhabitants. The capital is the city of the same name the seat of the boards of the departmental government, and of the courts of law. It contains 520 houses, with 3340 inhabitants, employed in making woollen goods, and in tanneries. In the vicinity are abundant mines of fossil coal. Long. 4. 31. E. Lat. 44. 45. N.

PRIVATEERS are a kind of men-of-war, fitted out and provided with military stores by private individuals; and the persons concerned, instead of pay, are permitted to retain their captures, allowing the admiral his share.

Privateers may not attempt any thing against the laws of nations; as to assault an enemy in a port or haven under the protection of any prince or republic, whether he be friend, ally, or neutral; and before a commission can be granted to any privateer, the commander is to give security, if the ship be not above 150 tons, in L.1500, and if the ship exceeds that burden, in L.3000, that the owners will make satisfaction for all damages which they shall commit in their courses at sea.

Besides these private commissions, there are special commissions for privateers, granted to commanders of ships and others, who take pay, are under a marine discipline, and, if they do not obey their orders, may be punished with death.

PRIVATIVE, in *Grammar*, a particle, which, prefixed to a word, changes it into a contrary sense. Thus, among the Greeks, the α is used as a privative; as in α-$\theta\iota o\varsigma$, *atheist*, *acephalus*, and the like.

PRIVY-Council. The king's will is the sole constituent of a privy-counsellor; and it also regulates their number, which in ancient times was about twelve. Afterwards it increased to so large a number that it was found inconvenient for secrecy and despatch; and therefore Charles II. in 1679 limited it to thirty. Since that time, however, the number has been much augmented, and now continues indefinite. Privy-counsellors are made by the king's nomination, without either patent or grant; and, on taking the necessary oaths, they become immediately privy-counsellors during the life of the king that chooses them, but subject to removal at his discretion.

The privy-council is the *primum mobile* of the state, and that which gives the motion and direction to all the inferior parts. It is likewise a court of justice of great antiquity; the primitive and ordinary way of government in England being by the king and privy-council. At present the privy-council takes cognizance of few or no matters except such as cannot well be determined by the known laws and ordinary courts; such as matters of complaint and sudden emergencies; their constant business being to consult for the public good in affairs of state.

In plantation or admiralty causes, which arise out of the jurisdiction of this kingdom, the privy-council has cognizance, being the court of appeal in such causes; and from all the dominions of the crown, excepting Great Britain and Ireland, an appellate jurisdiction (in the last resort) is vested in this tribunal, which usually exercises its judicial authority in a committee of the whole privy-council, who hear the allegations and proofs, and make their report to his majesty in council, by whom the judgment is finally given.

By the common law, the privy-council was dissolved *ipso facto* by the king's demise. But now, to prevent the inconveniences of having no council at the accession of a new prince, it is enacted, by 6 Anne, cap. 7, that the privy-council shall continue for six months after the demise of the crown, unless sooner determined by the successor. (Blackstone's *Commentaries*, book i.)

PRIZE, or Prise, in maritime affairs, a vessel taken at sea from the enemies of a state, or from pirates; and that either by a man-of-war, a privateer, or other, having a commission for that purpose.

PROBABILITY.

Probability

THE doctrine of probability is an extensive and very important branch of mathematical science, the object of which is to reduce to calculation the reasons which we have for believing or expecting any contingent event, or for assenting to any conclusion which is not necessarily true. When it is considered that the whole edifice of human science, with the exception of a few self-evident truths, such as the axioms of geometry, is nothing more than an assemblage of propositions which can only be pronounced to be more or less probable, the importance of a calculus which enables us to appreciate exactly the degree of probability existing in each case, will be readily understood.

Our reasons for judging an event to be probable or improbable, are derived from two distinct sources; first, an *a priori* knowledge of the causes or circumstances which determine its occurrence; and, secondly, when the causes are unknown, experience of what has already happened in the same circumstances, or in circumstances apparently similar. Suppose, for example, a hundred white balls to be placed in an urn along with fifty black balls, and that a person, blindfold, proceeds to draw a ball, there is to us, who are acquainted with the contents of the urn, a determinate probability that the ball which is drawn will be white. The balls being supposed to be all in precisely the same circumstances with respect to facility of drawing, we assume that there is the same chance of drawing any one ball as of drawing any other; and, consequently, since there are two white balls for each black ball, and therefore two chances of drawing one of the first colour for each chance of drawing one of the second, we conclude the event which consists in the drawing of a white ball to be twice as probable as the opposite event, or the drawing of a black ball. In this case our knowledge of the contents of the urn enables us to judge of the probable result of the drawing. Suppose, however, that antecedently to the drawing, we were entirely ignorant of the contents of the urn, but that after a great number of trials have been made, (the ball drawn being always replaced in the urn after each trial, in order that the circumstances may be the same in all the trials) it has been observed that a white ball has been drawn twice as often as a black ball, we presume that the urn contains twice as many white as black balls, and consequently affords twice as many chances of drawing a white ball as of drawing a black; and this presumption becomes stronger in proportion to the number of instances included in the observation. In this case experience makes up for the want of *a priori* knowledge, and affords a measure of the probability of the result of a future trial.

It is only in a comparatively small number of cases that all the possible ways in which an event may happen are known *a priori*, and in which, consequently, the ratio of the number of chances favouring the event to the whole number of existing chances is determinate. In fact, most of the questions of this class to which the calculus can be applied, are connected with lotteries and games of hazard. The results obtained from the analysis of such questions cannot be considered as being of any great value in themselves, but they frequently throw light on subjects of far higher importance which present analogous combinations. It is true that the mathematical theory comes in aid of moral considerations, and demonstrates the ruinous tendency of gambling even when the conditions of the play are equal, mathematically speaking; but, unfortunately, those who indulge a passion for this vice are seldom capable of appreciating the force of such arguments. The principal advantage which has resulted from the application of analysis to games of chance is the extension and improvement of the calculus to which it has led.

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The calculation of the probabilities of events, the chances of which are not known *a priori*, but inferred from experience, is founded on the presumed constancy of the laws of nature, in obedience to which events depending on constant though unknown causes, are always reproduced in the same order when considered in large numbers. Among the various phenomena of the physical and moral world, nothing is more remarkable than the constancy which is observed to prevail in the recurrence of events of the same kind. The ratio of male to female births furnishes a noted instance. If we consider only a small number of births, nothing can be more uncertain than the result; but taking a very large number, as those of a whole kingdom in the course of a year, the proportion of males to females is found to be almost invariable, and nearly as 21 to 20. The mean duration of human life affords another familiar example. Notwithstanding the proverbial uncertainty of life, the differences of constitutions, and the various accidents to which mankind are exposed, the average duration of the lives of a large number of individuals living in the same country is always found to be very nearly the same, insomuch that pecuniary risks depending on it, if undertaken in sufficiently large numbers, are among the least uncertain of all commercial speculations. A similar constancy is remarked in the results of statistical inquiries of every kind. The number of crimes of the same species committed in a year, the ratio of the number of acquittals to the number of trials, the number of conflagrations, of ships lost in a particular trade, of letters which pass through the post-office, of patients admitted into the public hospitals; in every case the numbers in a given time are observed to fluctuate between very narrow limits, and to approach nearer and nearer, as the observation is more extended, to fixed mean values.

This constant approximation to fixed ratios, which is proved by all experience, in the recurrence of events of the same kind, enables us to apply the calculus of probabilities to many of the most interesting questions connected with our social and political institutions; and to determine the average result of a series of coming events with as much precision as if their chances were determinate, and known *a priori*, like that of obtaining a given point with the throw of a die. Whatever be the nature of the phenomenon under consideration, whether it belong to the physical or moral order of things, the calculus is equally applicable when the requisite data have been determined from experience.

The foundations of the mathematical theory of probabilities were laid by Pascal and Fermat about the middle of the 17th century. Among some other questions relating to chances, the following was proposed to Pascal. "Two persons sit down to play on the condition that the one who first gains three games shall be the winner of the stakes. The first having gained two games, and the second one, they agree to leave off and divide the stakes in proportion to their respective probabilities of winning: what share is each entitled to take?" Pascal solved the question, but by a method which was applicable only to the particular case. Fermat, to whom it was communicated by Pascal, employed the direct and general method of combinations, and gave a solution which could be applied to the case of any number of players. His reasoning, however, did not at first appear to Pascal to be satisfactory, and a correspondence on the subject took place between these two illustrious

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geometers, which is preserved in their respective works, and throws some light on the history of mathematics in that age.[1]

About the same period Huygens composed his tract *De Ratiociniis in Ludis Aleæ*, which was first published in the *Exercitationes Geometricæ* of Schooten in 1658. This was the first systematic treatise which appeared on the doctrine of chances. It contained an analysis of the various questions which had been solved by Pascal and Fermat, and at the end five new questions were proposed, the solutions of which, simple as they may now appear, were then attended with considerable difficulty. The analysis of two of them was in fact given for the first time by Montmort, half a century after their publication. Huygen's tract was translated into English and published in 1692, with some additional remarks relative to the advantage of the banker in the game of Pharaon, in an *Essay on the Laws of Chance*, edited and supposed to have been written by Motte, then Secretary of the Royal Society.

James Bernoulli appears to have been the first who perceived that the theory of probability may be applied to much more important purposes than to regulate the stakes and expectations of gamesters, and that the phenomena, both of the moral and physical world, anomalous and irregular as they appear when viewed in detail, exhibit, when considered in large numbers, a constancy of succession which renders their occurrence capable of being submitted to numerical estimation. The *Ars Conjectandi*, published in 1713, seven years after the death of the author, contains a number of interesting questions relative to combinations and infinite series; but the most remarkable result which it contains is a theorem respecting the indefinite repetition of events, which may be said to form the basis of all the higher applications of the theory. It consists in this, that if a series of trials be instituted respecting an event which must either happen or fail in each trial, the probability becomes greater and greater, as the number of trials is increased, that the ratio of the number of times it happens, to the whole number of trials, will be equal to its *a priori* probability in a single trial; and that the number of trials may be made so great as to give a probability, approaching as nearly to certainty as we please, that the difference between the ratio of its occurrences to the number of trials, and the fraction which measures its *a priori* probability, will be less than any assigned quantity. Bernoulli informs us, that the solution of this important theorem had engaged his attention during a period of twenty years.

In the interval between the death of Bernoulli and the appearance of the *Ars Conjectandi*, Montmort published his *Essai d'Analyse sur les Jeux de Hazard*. The first edition was in 1708; the second, which is considerably extended, and enriched by several letters of John and Nicolas Bernoulli, appeared in 1713. The work possesses considerable merit; but being chiefly confined to the examination of the conditions of games of chance, many of which are now forgotten, it has lost much of its original interest.

About the same time, Demoivre began to turn his attention to the subject of probability, and his labours, which were continued during a long life, contributed greatly to the advancement of the general theory, as well as the extension of some of its most interesting applications. Demoivre's first publication on the subject was a Latin memoir *De Mensura Sortis*, in the *Transactions of the Royal Society* for 1711. His *Essay on the Doctrine of Chances* first appeared in 1716; a second edition in 1738; but the third and most valuable, including also his *Treatise on Annuities on Lives*, is dated 1756. This work contains a great variety of questions relating to chances, solved with much clearness and elegance; but it is chiefly remarkable for the theory of recurring series, there given for the first time, which is of important use in investigations of this kind, and is in fact equivalent to the methods employed in the modern calculus for the integration of equations of finite differences having constant co-efficients. Of the particular results obtained by Demoivre, one of the most important in reference to theory, is an extension of the theorem of James Bernoulli, above mentioned. It follows from Bernoulli's theorem, that if we have a given probability that the ratio of the number of occurrences of an event to the whole number of trials, will approach to the *a priori* probability of the event within certain given limits, those limits will become narrower and narrower, as the number of trials is multiplied; but in order to complete the theorem, it is necessary to assign the numerical value of the probability that in a large number of future trials, the number of occurrences will fall within assigned limits. For this purpose we must find the product of the natural numbers 1, 2, 3, 4, &c., up to the number of trials; an operation which, if attempted by direct multiplication, becomes very laborious, even when the number of trials is inconsiderable, and when the number is great, as 10,000 for example, is altogether beyond the reach of human industry. A formula was however discovered by Stirling, by means of which an approximate value of the product is found by the summation of a few of the first terms of a series which converges the more rapidly as the number of trials is greater. With the aid of this formula, Demoivre was enabled to assign the probability in question, and thus give a practical value to the theorem of Bernoulli.

The objects and important applications of the theory of probabilities having been made known by the works now mentioned, the subject has ever since been regarded as one of the most curious and interesting branches of mathematical speculation, and accordingly has received more or less attention from almost every mathematician of eminence. A great variety of questions connected with it and especially relating to lotteries, are interspersed in the volumes of the *Paris* and *Berlin Memoirs*, (particularly the latter,) by John and Nicolas Bernoulli, Euler, Lambert, Beguelin, and others. D'Alembert has likewise treated of the theory in several of the volumes of his *Opuscula;* and it is not a little remarkable, that in some instances its first principles should have been misunderstood by so ingenious and profound a writer. In the St. Petersburg Memoirs, (vol. v.) there is an interesting paper by Daniel Bernoulli on the relative values of the expectations of individuals who engage in play, or stake sums on contingent benefits, when regard is had to the difference of their fortunes; a consideration which, in many cases, it is necessary to take into account; for it is obvious, that the value of a sum of money to an individual, depends not merely on its absolute amount, but also on his previous wealth. On this principle Bernoulli has founded a theory of *moral expectation*, which admits of numerous and important applications to the ordinary affairs of life. The *Transactions of the Royal Society* for the years 1763 and 1764, contain two papers by the Rev. Mr. Bayes, with additions to the latter by Dr. Price, which deserve to be noticed, inasmuch as the principles on which the probability of an event is determined, when the event depends on causes of which the existence and influence are only presumed from experience, are there for the first time correctly laid down. The question proposed and solved by Bayes was this: a series of experiments having been made relative to an event, to determine the presumption there is, that the fraction which measures its probability falls within given limits.

One of the earliest applications of the theory of probability was to determine, from observations of mortality, the average duration of human life, and the value of pecuniary interests depending on its continuance or failure. This particular application appears to have been first thought of,

[1] *Œuvres de Blaise Pascal*, tome iv. Paris, 1819; *Opera Petri de Fermat*, Tolosæ, 1679.

or at least attempted to be carried into practical effect, in Holland, by Hudde and the celebrated pensionary De Witt; but the first tables of mortality, with the corresponding values of annuities on single lives, were constructed by our illustrious countryman Dr. Halley, and published in the Philosophical Transactions for 1693. For the history of this branch of the subject, we refer to the two articles, ANNUITIES and MORTALITY in this work. We may remark, however, that although the English writers, who have expressly treated of it, have almost without exception confined themselves to the explanation of the methods of computing annuity tables, and of determining from them the values of sums depending on life contingencies, the aid which this branch of economy derives from the general theory of probabilities, is by no means confined to the consideration of such elementary questions. The number of observations necessary to inspire confidence in the tables, the extent to which risks may be safely undertaken, the comparative weights of different sets of observations, and the probable limits of departure from the average results of previous observations in a given number of future instances, are all questions of the utmost importance, which come within the scope of the calculus, and cannot, in fact, be justly appreciated by any other means.

The application of the theory of probability to the subject of jurisprudence, and the verdicts of juries and decisions of tribunals, has been discussed by the Marquis Condorcet in various articles in the *Encyclopédie Méthodique;* but more especially in his *Essai sur l'application de l'Analyse à la Probabilité des Decisions rendues à la Pluralité des Voix*, Paris 1785; a work of great ingenuity, and abounding with interesting remarks on subjects of the highest importance to humanity. James Bernoulli, it appears, had intended to treat jurisprudence as a branch of probability in the *Ars Conjectandi*, but his premature death prevented that work from being completed. There is a memoir on the subject by his nephew Nicolas, in the Leipsic Acts for 1711. The most important questions to be determined, are the number of jurors of which a jury ought to consist, and the majority which should be required to agree in a verdict in order to afford, on the one hand, the greatest probability that an accused person will not be wrongly condemned; and, on the other, to give to society the greatest security that its interests will not be compromised, by allowing too great facilities for the guilty to escape. This important subject has been treated more profoundly, and with numerical elements derived from much better data than existed in the time of Condorcet, in a recent work by Poisson, to which we shall presently allude.

Another of the moral subjects to which the theory of probability has been applied, and connected with the preceding, is the appreciation of the evidence of testimony. In matters of this kind, it is easy to see that the calculus must be founded almost entirely upon hypothetical data. The veracity of a witness can scarcely be made the subject of direct experiment; and by reason of the complicated circumstances with which the facts forming the subject of testimony are usually accompanied, and the numberless ways in which mankind are influenced by their passions, credulity, or ignorance, it is perhaps equally impossible to deduce an average value from the comparison of a great number of statements which have been ascertained to be true or false. Numerical results can therefore only be obtained by having recourse to hypotheses, and consequently must be considered as only probable approximations. The knowledge, however, which is thus obtained of the various combinations of the quantities concerned, affords important aid in guiding our judgments in complicated cases, and when we have to decide upon conflicting testimony. Approximations deduced from a train of accurate and systematic reasoning, are always to be preferred to the most specious arguments drawn from any other source.

The analysis of probability has been applied with signal advantage in many researches of Natural Philosophy, but especially in appreciating the mean errors of observations. Owing to the imperfections of sense and of instruments, physical magnitudes are only susceptible of being measured within certain limits of accuracy; and where the last degree of precision is indispensable, as in practical astronomy, it is only by means of a very great number of measures, compared with one another, and combined according to the methods which this calculus points out, that we can obtain the nearest approximation to the true values which the observations are capable of giving. The mean errors of observations were treated as questions of probability by Lagrange in the Turin *Memoirs* for 1773; but it is to Laplace that the theory owes its principal extension and most important results. The method of combining numerous equations of condition now universally followed, known as the method of *minimum squares*, and which Laplace has demonstrated to be that which leaves the least probable amount of error in the final equations, was made known by Legendre in an Appendix to his *Nouvelles Méthodes pour la Détermination des Orbites des Comètes*, published in 1806. A similar method, however, or rather the same, (for they are identical in principle,) had been discovered by Gauss, and employed by him for several years before the work of Legendre made its appearance.[1]

Laplace's great work, the *Théorie Analytique des Probabilités*, first published in 1812, is one of the most remarkable productions that has ever appeared in abstract science. The principles of the calculus, as well as the peculiar methods of analysis which it requires, and the most interesting and difficult questions which it presents, are here discussed in a far more general manner than had been attempted by any former writer on the subject; and it may be said, accordingly, to have placed the theory under an entirely new aspect. It is much to be regretted that so little pains have been taken by the illustrious author to render the work intelligible to the generality of mathematical readers. Consisting for the greater part of separate memoirs presented at different times to the Academy of Sciences, arranged without regard to symmetry or order, it abounds with repetitions which only serve to embarrass the student; while the deficiency of explanation combined with the subtlety of the analysis, and the inherent intricacy of the subject, render it often a painfully difficult task to seize the force of the demonstrations. Notwithstanding these defects, however, it forms one of the most splendid creations of mathematical genius; and is alike admirable, whether we regard the extension which has been given to the calculus, or the results which have been arrived at, or the tone of lofty philosophy in which subjects bearing on some of the most important concerns of mankind are treated.

Next to the *Théorie Analytique* of Laplace, the most important work which has hitherto appeared on the subject of probability is the recent one of Poisson, entitled, *Recherches sur la Probabilité des Jugements*, (Paris 1837.) Although it might be inferred from the title that this work relates only to a single though very interesting application of the theory, the greater part of it is devoted to the development and demonstration of the general principles, and the discussion of the principal questions which present themselves in the different applications; and it is only in the last of the five books of which it consists that the special subject to which the title refers is taken into consideration. In applying the theory to the decisions of tribunals, Condorcet and Laplace had been unable to obtain positive results from the want of authentic data; but the recent publication by the French government of the *Comptes Généraux de l'Administration de la Justice Criminelle*, in France, having furnished an immense collec-

[1] *Theoria Motus Corporum Cœlestium*, p. 221.

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tion of facts from which the requisite data could be obtained, Poisson was led to consider the subject anew, and the results of his investigations, which are of singular interest, are given in the work now mentioned. Poisson had already given a theory of the mean errors of observations in the *Additions* to the *Connaissance des Tems* for 1827 and 1832.

It is in these two works of Laplace and Poisson that the higher and more abstruse parts of the theory of probabilities must be studied. A very clear exposition of the principles, accompanied with many interesting remarks on the uses and applications of the theory, is given by Lacroix in his valuable little work, *Traité Elémentaire du Calcul des Probabilités*, Paris 1822.

Since the time of Demoivre, the English treatises on the general theory of probability have neither been numerous, nor, with one or two exceptions, very important. Simpson's *Laws of Chance* (1740) contains a considerable number of examples, in the solution of which the author displays his usual acuteness and originality, but as they belong entirely to that class in which the chances are known *a priori*, they give no idea of the most interesting applications of the theory. Dodson's *Mathematical Repository* contains a large selection of the same kind. The Essay in the *Library of Useful Knowledge*, by Mr. Lubbock, gives a more comprehensive and philosophical, though an elementary view of the subject; but by far the most valuable work in the language is the Treatise in the *Encyclopedia Metropolitana*, by Professor De Morgan, 1837. In this very able production, Mr. De Morgan has treated the subject in its utmost generality, and embodied, within a moderate compass, the substance of the great work of Laplace.

Within the limits to which the present article must be confined, it would be hopeless to attempt giving a complete view of a branch of science which embraces so many complicated and intricate subjects of research, and which requires the aid of some of the most abstruse and recondite theories of the modern mathematics. In the higher applications of the theory, the analysis of many of the questions which arise, in order to be made intelligible, would require an extent of development and a parade of mathematical formulæ altogether incompatible with the plan and scope of this work. All that we can propose to ourselves, therefore, is to explain as briefly as may appear consistent with perspicuity, the general principles of the theory, and to give an outline of the manner in which these are applied to some of the more important questions which have been investigated by Laplace and Poisson. The examples will be selected with a view to shew the nature of the principal results of the mathematical theory, as well as the peculiar methods of analysis which are of most general application.

SECT. I. GENERAL PRINCIPLES OF THE THEORY OF PROBABILITY.

1. The term *probable*, in its popular acceptation, is used in reference to any unknown or future event, to denote that in our judgment the event is more likely to be true than not, or more likely to happen than not to happen. Without attempting to make an accurate enumeration of the various circumstances which are favourable or unfavourable to its occurrence, or to balance their respective influences, we suppose there is a preponderance on one side, and accordingly pronounce it to be probable that the event has occurred, or will occur, or the contrary.

2. If we can see no reason why an event is more likely to happen than not to happen, we say it is a *chance* whether the event will happen or not; or if it may happen in more ways than one, and we have no reason for supposing it will happen in any one of these ways rather than in another, we say it is a *chance* whether it will happen in any assigned way or in any other. Suppose, for example, an unknown number of balls of different colours to be placed in an urn, from which a ball is about to be extracted by a person blindfold. Here we have no reason for supposing that the ball about to be drawn will be of one colour rather than another, that it will be white rather than black, or red; and accordingly say it is a *chance* whether the ball will come out of a particular colour, or a different. In this instance, then, the term *chance* denotes, simply, the absence of a known cause. If, however, we are made acquainted with the number of balls in the urn, and the number there are of each of the different colours, the term is used in a definite sense. For instance, suppose the urn to contain ten balls, of which nine are white, and the remaining one black, we say there are nine chances in favour of drawing a white ball, and one chance only in favour of drawing the black ball. Chance, in this sense, denotes a *way of happening*, or a particular *case* or *combination* that may arise out of a number of other possible cases or combinations; and an event becomes probable or improbable according as the number of chances in its favour is greater or less than the number against it. *Chance* and *presumption* are also frequently used synonymously with *probability*.

3. The *mathematical probability* of any event is the ratio of the number of ways in which that event may happen to the whole number of ways in which it may either happen or fail. Thus, recurring to the previous example, the event, namely, the drawing of a ball from an urn containing 9 white balls and 1 black, may happen in 10 different ways, inasmuch as any one of the 10 balls may be drawn; but in one only of those ways will the event be a black ball; and therefore the probability of drawing the black ball is $\frac{1}{10}$. In like manner, as there are 9 different ways in which a white ball may be drawn, or 9 chances of drawing a white ball, and ten chances in all, the probability of drawing a white ball at the first trial is $\frac{9}{10}$. It follows immediately from this definition, that the probability of drawing a ball of either colour will remain the same, however the number of balls in the urn may be increased, provided those of each colour are increased in the same proportion. For instance, suppose the number of white balls to be 45, and the number of black balls to be 5; the number of chances in favour of drawing a black ball is 5, while there are 50 chances in all, consequently the probability of a black ball being drawn is $\frac{5}{50}=\frac{1}{10}$. In the same manner, the probability of drawing a white ball is $\frac{45}{50}=\frac{9}{10}$; the same as before. Generally, let E and F be two contrary events, that is to say, such that the one or the other of them must necessarily happen, and both cannot happen together; and let a be the number of chances or combinations which produce the event E, and b be the number of combinations which produce the event F, or cause the failure of E; then the probability that E will happen is $\frac{a}{a+b}$; and the probability that F will happen, or that E will *not* happen is $\frac{b}{b+a}$. In future, the term probability will be used only to signify mathematical probability.

4. It is to be carefully remarked, that the different chances or combinations which form the elements of probability are supposed to be perfectly equal. If this equality does not hold, and there is any circumstance respecting the event under consideration which renders one combination or set of combinations more likely to occur than another, the different combinations must be multiplied by numbers proportional to their respective facilities, after which the units in each multiplier may be regarded as so many distinct chances, from which the probability of the event will be found by the above formula. This is equivalent to saying that a combination or chance which is twice as likely to happen as another, must be regarded as two equal and similar combinations in comparison of that other; a proposition which is sufficiently obvious.

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5. It follows from the above definition, that the probability of any contingent event is measured by a fraction less than unity, and may have any value between 0 and 1. It follows, also, that the sum of the two fractions which measure the probabilities of two contrary events is equal to unit, which is the measure of certainty, inasmuch as either the one or the other necessarily occurs. Thus, in the last example, the probability of the event E is $\frac{a}{a+b}$, and that of the contrary event F is $\frac{b}{a+b}$, and $\frac{a}{a+b}+\frac{b}{a+b}=1$. Hence if p denote the probability of any event E, and q the probability of the contrary event F, we have $q=1-p$. This consequence of the definition is of great importance in the calculation of probabilities.

6. We have here supposed the result of a trial to be necessarily one or other of two events E and F; but it is easy to imagine the trial to be of such a kind that it may give rise to any one of a number of events E, F, G, H, &c. each having a given number of chances in its favour. This case is represented by supposing an urn to contain balls of as many different colours or sorts as there are different events. Let the urn be conceived to contain a balls of the sort which produces the event E, b of the sort which produces F, c of the sort which produces G, and so on; and let $a+b+c+d$, &c. $=k$, so that k is the whole number of balls in the urn. The probabilities of the different events E, F, G, H, &c. are then, respectively, by the definition,

$$\frac{a}{k}, \frac{b}{k}, \frac{c}{k}, \frac{d}{k}, \text{ \&c.}$$

the sum of which $=1$. In fact, if a ball be drawn at all, it must be of one or other of the different sorts contained in the urn; and consequently the sum of all the probabilities amounts to unit or certainty.

7. When an event is compounded of two or more simple events independent of each other, the probability of the compound event is equal to the product of the probabilities of the several simple events of which it is compounded. Let us imagine two urns, A and B, of which A contains a white balls and b black, and B contains a' white and b' black. Make $a+b=c$, and $a'+b'=c'$, and let the compound event whose probability is to be determined be the drawing of a white ball from both urns. Now, as each of the c balls in A may be drawn with any one of the c' balls in B, the whole number of ways in which the balls in A may be differently combined by pairs with the balls in B, or the whole number of possible cases is cc'. But the number of cases favourable to the compound event is evidently the number of different ways in which a white ball may be drawn from A with a white ball from B, and therefore equal to aa'. Hence by the definition (4), the probability that a white ball will be drawn from both urns is $\frac{aa'}{cc'}$. Now, if p denote the probability of drawing a white ball from A, and p' that of drawing a white ball from B, we have by the definition $p=\frac{a}{c}$, and $p'=\frac{a'}{c'}$; whence $\frac{aa'}{cc'}=pp'$.

In general, let p denote the probability of an event E, p' that of another event E′, p'' that of a third E″, and so on; then the probability of the concourse of the events E, E′, E″, &c., or the probability that they will all happen, is $p\times p'\times p''$, &c.; that is to say, the probability of an event compounded of any number of simple and independent events, is the product of the respective probabilities of the several simple events.

The probabilities that the several simple events E, E′, E,″ &c., will *not* all happen, or that some of them will happen and others fail, are easily determined in the same manner; it will be sufficient to indicate their several expressions. Suppose there are only three simple events, of which the probabilities are respectively p, p', and p''; and let $q=1-p$, $q'=1-p'$, $q''=1-p''$. The product $pq'q''$ expresses the probability of the compound event which consists in E happening and E′ and E″ both failing; $qp'q''$ is the probability that E′ will happen, and that E and E″ will both fail; $pp'p''$ is the probability they will all three happen; $1-pp'p''$ is the probability they will *not* all three happen, or that one of them *at least* will fail; $qq'q''$ is the probability they will all fail; and $1-qq'q''$ is the probability they will *not* all three fail, or that one *at least* of them will happen.

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8. As an example of the application of this rule, suppose it were required to assign the probability of throwing aces, at one throw, with two common dice. As a common die has six symmetrical faces, there are in respect of each die six ways equally possible, in which the simple event may happen. The probability therefore of throwing ace with one die is $\frac{1}{6}$, that is, $p=\frac{1}{6}$. In respect of the second die, we have also $p'=\frac{1}{6}$; hence the probability of the compound event, or that aces will be thrown is $pp'=\frac{1}{6}\times\frac{1}{6}=\frac{1}{36}$. The probability that aces will *not* be thrown at any assigned trial is therefore (5) $1-\frac{1}{36}=\frac{35}{36}$; and the *odds* against throwing aces at any given trial are 35 to 1.

Again, suppose two numbers, each consisting of 7 digits, to be taken at random, (for instance from a table of logarithms), and let it be proposed to assign the probability that the substraction of the one from the other will be performed without its being necessary, in any case, to increase the upper figure. Here, as each digit may have any one of the ten values from 0 to 9 both inclusive, and as each of those values in the upper line may be combined with any one of them in the lower line, there are 100 different combinations or equally possible cases for each partial substraction. Now, if the upper figure be 0, there is only one of those cases favourable to the event, or which will admit of the substraction being performed, namely, when the figure below is also 0. If the upper figure be 1, there are two cases favourable, namely, those in which the under figure is 0 or 1. If the upper figure be 2, there are three favourable cases, namely, when the under figure is 0, 1, or 2. Proceeding in this way through all the digits, the whole number of favourable cases is found to be

$$1+2+3+4+5+6+7+8+9+10=55.$$

Hence, for each partial substraction there are 55 favourable cases out of 100 possible cases; therefore (4) the probability that any one of the figures in the upper line is not less than the corresponding figure in the under line is $\frac{55}{100}$; and we have $p=p'=p''=\text{\&c.}=\frac{55}{100}$ for the probability of each of the seven simple events or partial substractions, whence, by (7), the probability of the compound event is

$$p\times p'\times p''\times \text{\&c.}=\left(\frac{55}{100}\right)^7=(\cdot55)^7=0152243,$$

which is less than $\frac{1}{63}$, and greater than $\frac{1}{66}$.

9. When an event may happen in several different ways, each independent of the others, the probability of the event is the sum of all the partial probabilities taken in respect of each of the different ways.

Suppose there are n different urns A_1, A_2, A_3.....A_n, each containing balls of two colours, white and black, and let the whole number of balls in each urn respectively, be

$$c_1, c_2, c_3, \ldots\ldots c_n,$$

and the number of white balls in each be

$$a_1, a_2, a_3, \ldots\ldots a_n,$$

and let the event E be the extraction of a white ball in drawing a ball from any urn at random. In this case there are n different ways, all equally probable, in which the event may happen, for it may be drawn with equal facility from any one of the urns. The probability that the ball will be

Probability drawn from any given urn, A_1, is therefore $\frac{1}{n}$; and if it be drawn from this urn, the probability of its being white is $\frac{a_1}{c_1}$; therefore, by (7), the probability of a white ball being drawn from A_1 is $\frac{1}{n} \cdot \frac{a_1}{c_1}$. In like manner the probability of a white ball being drawn from A_2 is shewn to be $\frac{1}{n} \cdot \frac{a_2}{c_2}$; from A_3 to be $\frac{1}{n} \cdot \frac{a_3}{c_3}$, and so on. Denoting therefore by p the whole probability of the event E, the proposition affirms that

$$p = \frac{1}{n}\left(\frac{a_1}{c_1} + \frac{a_2}{c_2} + \frac{a_3}{c_3} \ldots\ldots + \frac{a_n}{c}\right).$$

To prove this, let the fractions $\frac{a_1}{c_1}, \frac{a_2}{c_2}$ &c. be reduced to a common denominator, and suppose the equivalent fractions to be

$$\frac{a_1}{\gamma}, \frac{a_2}{\gamma}, \frac{a_3}{\gamma} \ldots\ldots \frac{a_n}{\gamma}.$$

We may now conceive the urns $A_1, A_2, A_3 \ldots A_n$ to be replaced by others, each containing the same number, γ, of balls, and of which the first contains a_1 white balls, the second a_2, and so on; and it is evident that the chance of a white ball being drawn from this new system of urns will be precisely the same as it was for a white ball being drawn from the first system. Now the probability of drawing a white ball from the new system will not be altered by placing the whole of the $n\gamma$ balls in a single urn, for they may still be conceived as arranged in groups, disposed in any manner whatever, each group containing the same number of balls, and the same proportion of white to black as were in the separate urns; and as each group contains the same number of balls, the chance of laying the hand on any one group is the same as that of laying it on any other. The probability of drawing a white ball from the single urn, is therefore the same as for drawing it from the group of separate urns which contain each the same number of balls. But the probability of drawing it from the single urn is the ratio of the number of white balls contained in the urn to the number of both colours, therefore (this probability being p) we have

$$p = \frac{1}{n\gamma}(a_1 + a_2 + a_3 \ldots\ldots + a_n);$$

whence, substituting for $\frac{a_1}{\gamma}$, $\frac{a_2}{\gamma}$, &c., their respective values, $\frac{a_1}{c_1}$, $\frac{a_2}{c_2}$, &c., we have

$$p = \frac{1}{n}\left(\frac{a_1}{c_1} + \frac{a_2}{c_2} + \frac{a_3}{c_3} \ldots\ldots + \frac{a_n}{c_n}\right).$$

As a particular case suppose three urns A, B, C to be placed together, of which A contains 2 white balls and 1 black; B 3 white balls and 2 black, and C 4 white and 3 black, and let it be required to determine the probability p of a white ball being drawn from the group by a person who is ignorant of the contents of the different urns. As there is no reason for selecting one urn in preference to another, the probability that he will put his hand into the urn A is $\frac{1}{3}$; and if he draw from this urn the probability that a white ball will be drawn is $\frac{2}{3}$, there being 2 cases favourable to that event, and 3 cases in all. The probability of both events is therefore $\frac{1}{3} \quad \frac{2}{3} = \frac{2}{9}$. In like manner, the probability of the ball being drawn from B is $\frac{1}{3}$; and if drawn from B the probability of its being white is $\frac{3}{5}$; therefore, the probability of this compound event is $\frac{1}{3} \times \frac{3}{5} = \frac{1}{5}$. Lastly, the probability of the ball being drawn from C is $\frac{1}{3}$; and if drawn from C the probability of its being white is $\frac{4}{7}$; therefore, the probability of this compound event is $\frac{1}{3} \times \frac{4}{7} = \frac{4}{21}$. Hence, by the proposition now demonstrated, the complete probability of the event E is Probability

$$p = \frac{2}{9} + \frac{1}{5} + \frac{4}{21} = \frac{195}{315}.$$

If all the balls had been placed in a single urn, the probability of drawing a white ball would have been $\frac{9}{15}$, for there are $3 + 5 + 7 = 15$ balls in all, of which $2 + 3 + 4 = 9$ are white. But $\frac{9}{15} = \frac{189}{315}$; a fraction which differs sensibly from $\frac{195}{315}$, the measure of the probability of the same event when the balls are distributed in the manner above supposed amongst the different urns. The distinction between the two cases is important.

10. The rule laid down in (7) for finding the probability of a compound event applies alike whether the simple events are determined simultaneously or in succession. In fact, when the simple events are entirely independent of each other, the chances which determine the compound event are not influenced in any way by the intervention of time. Suppose, for example, the compound event to be the throwing of a certain number of points with a given number m of dice; the chances for and against the event are obviously the same whether the m dice are thrown at once, or a single die is thrown m times successively. But as the determination of the probability of a compound event is in general facilitated by supposing the simple events to be decided one after the other, it will be convenient to view the subject in this light in explaining the method of forming the different combinations of the chances by which the probabilities of compound events are determined.

SECT. II. OF THE PROBABILITY OF EVENTS DEPENDING ON A REPETITION OF TRIALS, OR COMPOUNDED OF ANY NUMBER OF SIMPLE EVENTS, THE CHANCES IN RESPECT OF WHICH ARE KNOWN *A PRIORI*, AND CONSTANT.

11. Suppose an urn to contain $a + b$ balls, a white and b black, and let a ball be successively drawn, and replaced in the urn after each drawing, in order that the chances in favour of drawing a ball of either colour may be the same in every trial, and let it be required to find the respective probabilities of the different possible results of any number of drawings.

Let us first suppose the number of trials to be two. The event may happen in any of these four different ways: first white, second white; first white, second black; first black, second white; first black, second black. Assuming W to represent the simple event which consists in the drawing of a white ball, and B that of a black ball, and supposing the order of the arrangement of the two letters to correspond with the order of succession of the simple events, the four possible cases or combinations will be represented thus:—

WW, WB, BW, BB.

Now let the probability of drawing a white ball in any trial be p, and that of drawing a black ball be q, (whence, $p = \frac{a}{a+b}$, $q = \frac{b}{a+b}$) the probabilities of the four possible compound events are by (7) respectively as under:

probability of WW $= p \times p = p^2$
of WB $= p \times q = pq$
of BW $= q \times p = pq$
of BB $= q \times q = q^2$

If we disregard the order of succession, and consider the two arrangements WB and BW, which are equally probable, as forming the same compound event, namely, a ball of both colours in the two trials, the probability of this event, by (9), becomes $2pq$. The sum of the probabilities of all the possible arrangements is therefore

$$p^2 + 2pq + q^2 = (p + q)^2;$$

whence it appears that the probabilities of the different arrangements in two trials are respectively the terms of the development of the binomial, $(p+q)^2$.

Let us next suppose the number of trials to be three.

Probability The different arrangements that may be formed of the simple events in three trials, with the probability of each respectively, are as follows :—

WWW, probability of which $=ppp=p^3$
WWB, ... $=ppq=p^2q$
WBW, ... $=pqp=p^2q$
BWW, ... $=qpp=p^2q$
WBB, ... $=pqq=pq^2$
BWB, ... $=qpq=pq^2$
BBW, ... $=qqp=pq^2$
B B B, ... $=qqq=q^3$

It thus appears that the probability of obtaining two events of one kind, and one of the other, is the same in whatever order they succeed each other, and, in fact, is independent of the order. Disregarding, then, the order of succession, and considering the combination of two white balls with one black, in whatever order they may be arranged, as the same compound event, the probability of its occurrence *in any order whatever*, being the sum of its probabilities in each particular order (9), is $3p^2q$. In like manner, regarding the combination of two black balls with one white, in any order of arrangement, as the same compound event, its probability is $3pq^2$. The compound event resulting from three trials must then happen in one of four different ways, namely, 3 white balls; 2 white, combined with1 black, in any order; 2 black, combined with one white, in any order; or, lastly, 3 black; and the sum of the probabilities of these different cases is

$$p^3+3p^2q+3pq^2+q^3=(p+q)^3.$$

Hence the probabilities of all the different possible combinations in three trials are respectively given by the development of the binomial $(p+q)^3$.

12. In general, let p denote the probability of any simple event E, then the probability of E happening twice in two trials is p^2, of happening thrice in 3 trials p^3, and of happening m times in m successive trials, p^m. In like manner, the probability of the contrary event F being q $(p+q=1)$, the probability of F happening n times in n successive trials is q^n. Hence (7) the probability of E happening m times, and then F happening n times in succession, in $m+n$ trials, is p^mq^n. But the probability of these events happening in any assigned order is the same as that of their happening in any other assigned order; therefore p^mq^n is the measure of the probability that E will occur m times, and F will occur n times in a determinate order. Now, let $m+n=h$, and let U be the number of different ways in which m events E, and n events F, can be combined in h trials, and P be the probability of any one of these combinations whatever, or the probability of E occurring m times, and F occurring n times in h trials, without regard to the order in which they succeed each other, we have then

$$P=Up^mq^n.$$

In order to determine the value of U, we may suppose the events in question to be so many different things represented by the letters A, B, C, D, E, &c. of which there are m of one kind, and n of another, and make $m+n=h$; then by the algebraic theory of combinations, we have

$$U=\frac{1\cdot2\cdot3\ldots\ldots h}{1\cdot2\cdot3\ldots\ldots m\times1\cdot2\cdot3\ldots\ldots n}.$$

This value of U is symmetrical in respect of m and n, and may be otherwise written in either of the two following forms,

$$U=\frac{h(h-1)(h-2)\ldots\ldots h-m+1}{1\cdot2\cdot3\quad\ldots\ldots\quad m},$$

$$U=\frac{h(h-1)(h-2)\ldots\ldots h-n+1}{1\cdot2\cdot3\quad\ldots\ldots\quad n},$$

which shew that the probability P, or the product Up^mq^n is the $(m+1)$th term of the development of the binomial $(p+q)^h$ arranged according to the increasing powers of p, or the $(n+1)$th term of the same development arranged according to the increasing powers of q. Hence Probability we conclude that when p and q remain constant, the probabilities of all the different compound events which can be formed by the combination of the simple events E and F in h trials, are expressed by the different terms of the formula $(p+q)^h$ expanded by the binomial theorem.

The whole number of possible cases is evidently $h+1$, for in h experiments, E may occur h times, h—1 times, h—2 times.....h—h times; this last being the case in which the contrary event F occurs in all the trials. The different cases are unequally probable, both by reason of the greater or smaller number of combinations by which they may be produced, and which in reference to each case is represented by U, and by reason of the inequality between p and q. It will be shewn afterwards, that when $p=q$, and h is a whole number, the most probable case is that in which the occurrences of E and F are equal; and if h is an odd number, the two most probable cases are those in which the difference in the number of occurrences of E and the number of occurrences of F is unity.

13. In order to place the proposition now demonstrated in a clearer light, let us consider separately the different terms of the development of $(p+q)^h$, namely,

$$p^h+hp^{h-1}q+\frac{h(h-1)}{1\cdot2}p^{h-2}q^2\ldots\ldots\ldots\ldots\ldots$$
$$+\frac{h(h-1)(h-2)\ldots\ldots h-n+1}{1\cdot2\cdot3\quad\ldots\ldots\quad n}p^{h-n}q^n$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots+q^h.$$

The first term p^h expresses the probability that the event E will in every one of the h trials. The second term $hp^{h-1}q$ expresses the probability that E will occur h—1 times, and F once, without distinction of order; that is to say F may happen at the first or last or any intermediate trial. If a determinate succession is proposed, for example, that of h—1 times the event E in succession, and F in the next trial, the probability of the event in the assigned order is found by suppressing the coefficient h, and is consequently $p^{h-1}q$.

The third term $\frac{h(h-1)}{1\cdot2}p^{h-2}q^2$ expresses the probability that the result of h trials will be h—2 times the event E, and twice the event F, without distinction of order. If a particular order be assigned, it is necessary to suppress the coefficient, and the probability of the simple events occurring in that particular order is $p^{h-2}q^2$.

The general term $\frac{h(h-1)(h-2)\ldots\ldots h-n+1}{1\cdot2\cdot3\quad\ldots\ldots\quad n}p^{h-n}q^n$ expresses the probability that the result of h trials will be $(h-n)$ times the event E, and n times the event F in any order. The probability of $(h-n)$ times E and n times F in an assigned order is $p^{h-n}q^n$.

14. If we suppose the event E to be such that the chances in favour of its happening or failing are equal, that is, if $p=q=\frac{1}{2}$, the different terms of the binomial $(p+q)^h$, on suppressing the coefficients, become all equal; so that a particular order being assigned in each of the possible cases or combinations, all the cases become equally probable. Thus, suppose a shilling to be tossed 100 times in succession, the probability of head turning up in every trial is $(\frac{1}{2})^{100}$. The probability of 50 heads and 50 tails in any assigned order is $(\frac{1}{2})^{50}\times(\frac{1}{2})^{50}=(\frac{1}{2})^{100}$; if $m+n=100$, the probability of m heads and n tails is also $(\frac{1}{2})^m(\frac{1}{2})^n=(\frac{1}{2})^{m+n}=(\frac{1}{2})^{100}$. Hence the probability of any compound event formed by the combination of two simple contrary events succeeding each other in an assigned order, and each having the same probability, is independent of the ratio of the simple events, and depends only on the number of trials. Before the trials, it is an even wager that head will be turned up in succession 100 times, and that the result of 100 trials will be 50 heads and 50 tails in a given order of succession, or any proportion

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of heads to tails in an order arbitrarily chosen. This consideration is frequently lost sight of in reasoning about those events of the natural world, which are termed extraordinary and miraculous. If in tossing a shilling 100 times into the air, the number of heads turned up is found nearly equal to the number of tails, the event excites no surprise; something like it was expected. On the contrary, if the difference between the number of heads and the number of tails is considerable, the event is termed extraordinary; and if head turned up in every trial without exception, we should scarcely be persuaded that such an event was entirely the result of chance, and independent of a special cause. Nevertheless, the *a priori* probability that every trial will give head, is precisely the same as the probability of throwing any given number of heads and tails in an assigned order of succession. It will, however, be proved afterwards, that if such an event as throwing head 100 times in succession were actually observed, the probability of a special cause having intervened, would approach very nearly to certainty.

15. Hitherto we have supposed the compound event to be formed by the combination of two simple events only, E and F, one of which necessarily excludes the other. Let us now suppose there are any number of simple events, E_1, E_2, E_3, &c. of which the respective probabilities are p_1, p_2, p_3, &c. and such that one or other of them necessarily happens in each trial, so that $p_1+p_2+p_3+$, &c.$=1$, and determine the probability of any assigned combination of them in a given number of trials. This case may be represented by supposing an urn to contain a number of balls of as many different colours as there are distinct events; the event E_i will be the drawing of a ball of the colour i, and its probability p_i will be the fraction whose numerator is equal to the number of balls of the colour i, and denominator the whole number of balls in the urn. Now the probability of the event E_1 happening m times in succession is p_1^m by (12); that of E_2 happening n times in succession is p_2^n; that of E_3 happening r times in succession p_3^r; and so on. Therefore (7) the probability of the compound event which is formed by the occurrence of m times E_1, n times E_2, r times E_3, and so on, these events succeeding each other in order, is the product $p_1^m\, p_2^n\, p_3^r$, &c. But the probability of the simple events succeeding each other in any particular order is the same as that of their succeeding in any other assigned order (12); consequently, if U′ denote the number of different ways in which m events E_1, n events E_2, r events E_3, &c. can be combined, or succeed each other, and P′ be the probability of the compound event in any order whatever, we have,

$$P'=U'p_1^m\, p_2^n\, p_3^r, \text{ \&c.}$$

Assuming $h=m+n+r+$, &c. we have also by the theory of combinations,

$$U'=\frac{1\,.\,2\,.\,3\ldots\ldots\ldots\ldots h}{1\,.\,2\,.\,3\ldots m\times 1\,.\,2\,.\,3\ldots n\times 1\,.\,2\,.\,3\ldots r\times \text{ \&c.}}$$

the factor U′ being the coefficient of the term which has for its multiplier $p_1^m\, p_2^n\, p_3^r$, &c. in the expansion of the multinomial $(p_1+p_2+p_3+$ &c.$)^h$, whence

$$P'=\frac{1\,.\,2\,.\,3\ldots\ldots\ldots\ldots h}{1.2.3\ldots m\times 1.2.3\ldots n\times 1.2.3\ldots r\times \&c.}p_1^m\, p_2^n\, p_3^r, \&c.$$

We shall now proceed to give some examples of the applications of the preceding formulæ.

16. Let it be proposed to assign the probability P, of throwing ace *once*, and not oftener, in four successive throws of the same die.—Simpson, p. 15.

Here, the chance of throwing ace in a single trial being $\frac{1}{6}$, we have $p=\frac{1}{6}$, and consequently $q=\frac{5}{6}$, and also $h=4$. Now the compound event being the occurrence of the simple event E, whose probability is p, once, and of the contrary event F three times, the probability of the compound event is that term of the development of $(p+q)^4$ which is multiplied by pq^3. If, therefore, in the formula,

$$P=\frac{1\,.\,2\,.\,3\ldots\ldots\ldots\ldots h}{1\,.\,2\,.\,3\ldots m\times 1\,.\,2\,.\,3\ldots\ldots n}p^m q^n,$$

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we make $p=\frac{1}{6}$, $q=\frac{5}{6}$, $h=4$, $m=1$, $n=3$, we shall have

$$P=\frac{1\,.\,2\,.\,3\,.\,4}{1\times 1\,.\,2\,.\,3}\times\frac{1}{6}\times\left(\frac{5}{6}\right)^3=\frac{125}{324},$$

which is the probability required, and the same as that of throwing one ace, and not more than one, at a single throw with 4 dice.

The probability of the contrary event, that is to say, the probability of either not throwing an ace at all, or of throwing more aces than one is $1-\frac{125}{324}=\frac{199}{324}$; and therefore the odds against throwing one ace and no more in 4 throws of a common die are 199 to 125, or 8 to 5 very nearly.

17. If in this example it had been proposed to assign the probability of throwing ace once *at least*, instead of once and not more, it would have been necessary to have included those cases in which the ace occurs twice, or three times, or in each of the four trials. The binomial $(p+q)^4$ gives

$$p^4+4p^3q+6p^2q^2+4pq^3+q^4,$$

the first term of which expresses the probability of throwing ace four times in succession; the second that of throwing ace three times, and another number once; the third that of throwing ace twice, and a different face twice; the fourth that of throwing ace once, and a different face three times; and the fifth that of throwing a different face in each of the four trials. But as every one of these compound events, excepting the last, satisfies the condition of ace being thrown once at least, the whole probability of that event must be the sum of the probabilities of the different events by which it may be produced (9) and is consequently

$$\left(\frac{1}{6}\right)^4+4\left(\frac{1}{6}\right)^3\frac{5}{6}+6\left(\frac{1}{6}\right)^2\left(\frac{5}{6}\right)^2+4\left(\frac{1}{6}\right)\left(\frac{5}{6}\right)^3=\frac{671}{1296}$$

In general, the sum of the first $n+1$ terms of $(p+q)^h$ expresses the probability of obtaining *not less* than $h-n$ events, the probability of each of which is p, or *not more* than n contrary events, the probability of each of which is q.

Since $p+q=1$, the sum of all the terms of the series produced by the expansion of $(p+q)^h$ is equal to unit, and therefore the sum of any number of the terms is equal to unit diminished by the sum of the remaining terms. This consideration frequently gives the means of abridging the calculations. Thus, in the preceding example, instead of expanding the binomial $(\frac{1}{6}+\frac{5}{6})^4$ in order to find the probabilities of throwing 4 aces, 3 aces, 2 aces, and 1 ace only, in a series of 4 trials, we might have sought the probability of not throwing ace at all. The probability of not throwing ace in a single trial is $\frac{5}{6}$, and therefore (7) that of not throwing it in 4 trials is $(\frac{5}{6})^4=\frac{625}{1296}$. Hence the probability of the contrary event, namely, that ace will be thrown once or oftener, is $1-\frac{625}{1296}=\frac{671}{1296}$; the same as before.

18. Let a shilling be tossed; what is the probability that more than 3 heads will turn up in the first 10 trials? In this case, $p=\frac{1}{2}$, $q=\frac{1}{2}$, $h=10$; therefore $(p+q)^h=(\frac{1}{2}+\frac{1}{2})^{10}=(\frac{1}{2})^{10}(1+1)^{10}$. Now the last term of this development expresses the probability that head will not turn up in any one of the ten trials; the last but one, the probability that it will turn up once; the last but two, the probability that it will turn up twice; and the last but three, the probability that it will turn up three times; therefore the four last terms include all the different ways in which the ten trials give not more than three heads; and their sum consequently expresses the probability that *not more* than 3 heads will be thrown. Now the last four (or first four) terms of the expansion of $(1+1)^{10}$ are

$$1,\ 10,\ \frac{10\,.\,9}{1\,.\,2},\ \frac{10\,.\,9\,.\,8}{1\,.\,2\ \ 3},$$

and their sum is 176, which multiplied by $(\frac{1}{2})^{10}=\frac{1}{1024}$, gives $\frac{176}{1024}$, for the probability that not more than 3 heads will turn up; whence the probability of the contrary event

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or that more than 3 heads will be thrown, is $1-\frac{176}{1024}=\frac{848}{1024}=\frac{53}{64}$; and the odds in favour of throwing heads more than three times in 10 trials are 53 to 11.

19. A and B engage in play; the probability of A's winning a game is p, and the probability of B's winning a game is q; required the probability P, of A's winning m games before B wins n games, the play being supposed to terminate when either of those events has occurred.

It is evident that the question must be decided *at the latest*, by the $(m+n-1)$th game; for supposing $m+n-2$ games to have been played, there is only one combination according to which the match can remain undecided, namely, that in which A has won $m-1$, and B $n-1$ games; and in this case the next game necessarily decides the match.

Suppose $m+x$ games to have been played. The probability that of these games m have been won by A, and x by B, is represented by the term of the binomial $(p+q)^{m+x}$ in which the factor $p^m q^x$ occurs (13); which term is

$$\frac{1\,.\,2\,.\,3\ldots\ldots m+x}{1\,.\,2\,.\,3\ldots\ldots m\times 1\,.\,2\,.\,3\ldots\ldots x}\,p^m q^x.$$

But A cannot win m games out of $m+x$ exactly unless he wins the last game, for otherwise he must have won m games out of $m+x-1$, if not out of a smaller number. In order therefore that A may win m games out of $m+x$ exactly, it is necessary in the first place that he wins $m-1$ out of $m+x-1$ in any order, and then that he wins also the next game. Now the probability of his winning $m-1$ games out of $m+x-1$ in any order (13) is

$$\frac{1\,.\,2\,.\,3\ldots\ldots m+x-1}{1\,.\,2\,.\,3\ldots m-1\times 1\,.\,2\,.\,3\ldots x}\,p^{m-1}q^x;$$

and the probability of his winning the following game is p, whence the probability of both events is (7)

$$\frac{1\,.\,2\,.\,3\ldots\ldots m+x-1}{1\,.\,2\,.\,3\ldots\ldots m-1\times 1\,.\,2\,.\,3\ldots\ldots x}\,p^m q^x,$$

which, therefore, expresses the probability of A's winning m games out of $m+x$ exactly.

If we suppose $x=0$, this formula becomes p^m, which is the probability of A's winning m games in succession. If $x=1$, it becomes $mp^m q$, the probability that A wins m games out of $m+1$. If $x=2$, it becomes $\frac{m(m+1)}{1\,.\,2}p^m q^2$, the probability that A wins m games out of $m+2$. If $x=3$, it becomes $\frac{m(m+1)(m+2)}{1\,.\,2\,.\,3}p^m q^3$, the probability that A wins m games out of $m+3$; and so on. Continuing this process till we arrive at the term multiplied by $p^m q^x$, the sum of the probabilities of all the different compound events is

$$p^m\left\{1+mq+\frac{m(m+1)}{1\,.\,2}q^2\ldots+\frac{m(m+1)\ldots m+x-1}{1\,.\,2\ \ldots\ \ x}q^x\right\};$$

which expresses the probability of A's winning m games out of a number *not greater* than $m+x$.

Now it has been shewn, that the match is necessarily decided by $(m+n-1)$ games; consequently the solution of the question is obtained by substituting $n-1$ for x in the last formula, which will then express the probability of A's winning m games in any order, out of a number not greater than $m+n-1$. On making this substitution, we obtain

$$\mathrm{P}=p^m\left\{1+mq+\frac{m(m+1)}{1\,.\,2}q^2\ldots\ldots\ldots\ldots\right.$$
$$\left.\ldots\ldots\ldots\ldots+\frac{m(m+1)\ldots m+n-2}{1\,.\,2\ \ldots\ \ n-1}q^{n-1}\right\}.$$

The probability Q that the match will be decided in favour of B, or that B will win n games out of a number not greater than $m+n-1$, is found by changing m into n, and p into q, and is therefore

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$$\mathrm{Q}=q^n\left\{1+np+\frac{n(n+1)}{1\,.\,2}p^2\ldots\ldots\ldots\ldots\right.$$
$$\left.\ldots\ldots\ldots\ldots+\frac{n(n+1)\ldots\ldots m+n-2}{1\,.\,2\ \ldots\ldots\ m-1}p^{n-1}\right\}.$$

As an example, let us suppose $p=\frac{2}{3}$, $q=\frac{1}{3}$, $m=4$, and $n=2$. The probability of A's winning the match, or the value of P, becomes

$$\left(\frac{2}{3}\right)^4\left\{1+4\cdot\frac{1}{3}\right\}=\frac{112}{243};$$

and the probability of B's winning the match, or the value of Q,

$$\left(\frac{1}{3}\right)^2\left\{1+\frac{4}{3}+\frac{2\,.\,3}{1\,.\,2}\left(\frac{2}{3}\right)^2+\frac{2\,.\,3\,.\,4}{1\,.\,2\,.\,3}\left(\frac{2}{3}\right)^3\right\}=\frac{131}{243}.$$

In this example the skill of A is supposed to be twice as great as that of B, and the number of games that must be won by him in order to gain the match is also twice as great as the number required to be won by B in order that B may gain; one might therefore suppose, that when they begin to play the chances in favour of each are equal. But the result shews that the chances in favour of A are fewer than those in favour of B in the proportion of 112 to 131; whence it appears that it would be unsafe to wager that a player who has two chances in his favour while his adversary has only one, will gain four games before his adversary shall have gained two.

Suppose A and B, engaged in play, agree to leave off before the match is decided, it is evident that the stakes ought to be shared between them in proportion to their respective probabilities of winning, and consequently the share of each is found from either of the above expressions for P and Q. This was one of the questions proposed by the Chevalier de Méré to the celebrated Pascal, to which allusion has already been made.

20. An urn contains $n+1$ balls, marked with the numbers 0, 1, 2, 3……n; a ball is successively drawn and replaced in the urn, so that the chance of drawing any given number remains the same in each trial, what is the probability that in h trials the sum of the numbers drawn will be equal to s?[1]

The solution of this problem depends on the number of ways in which the number s can be formed by the addition of h different numbers, each of which may have any value from 0 to n. If we suppose the numbers marked on the balls to be indexes of a certain quantity x, and develope the expression $(x^0+x^1+x^2\ldots\ldots+x^n)^h$, the coefficient of any term of the development will indicate the number of different ways in which the balls may be drawn, so that the sum of the numbers drawn in h trials shall be equal to the sum of the indexes of x in that term. If, therefore, we denote by N the coefficient of that term of the development in which the sum of the indexes is s, then N will be the number of cases favourable to the event. But the whole number of possible cases is $(n+1)^h$; therefore the probability of the event is $\mathrm{N}\div(n+1)^h$.

On account of the particular form of the polynomial in question, the value of N is found without difficulty.

Because $x^0+x^1+x^2\ldots\ldots+x^n=\frac{1-x^{n+1}}{1-x}$, therefore

$(x^0+x^1+x^2\ldots\ldots+x^n)^h=(1-x^{n+1})^h(1-x)^{-h}$. Now, expressing these two factors in series, we have $(1-x^{n+1})^h$

$$=1-hx^{n+1}+\frac{h(h-1)}{1\,.\,2}x^{2(n+1)}-\frac{h(h-1)(h-2)}{1\,.\,2\,.\,3}x^{3(n+1)}+\&c.$$

$$(1-x)^{-h}=1+hx+\frac{h(h+1)}{1\,.\,2}x^2+\frac{h(h+1)(h+2)}{1\,.\,2\,.\,3}x^3+\&c.;$$

and the coefficients of the several terms of the product of

[1] Demoivre, *Miscellanea Analytica*, p. 196; Laplace, *Essai sur les Probabilités*, p. 253, et seq.

Probability these two series in which the sum of the indexes is s will be found as follows:—

(1.) Multiply the first term of the first series by that term of the second series of which the argument is x^s; the coefficient of the product will be $\frac{h(h+1)(h+2).....h+s-1}{1.2.3 \quad ..... \quad s}$.

(2.) Multiply the second term of the first series by that term of the second series which has for its argument x^{s-n-1}; the coefficient of the product will be

$$-h \times \frac{h(h+1)(h+2).....h+s-n-2}{1.2.3 \quad ..... \quad s-n-1}.$$

(3.) Multiply the third term of the first series by that term of the second series which has for its argument $x^{s-2(n+1)}$; the coefficient of the product will be

$$\frac{h(h-1)}{1.2} \times \frac{h(h+1)(h+2).....h+s-2n-3}{1.2.3 \quad ..... \quad s-2n-2}.$$

(4.) Proceed in the same manner with the fourth term of the first series, and so on with the others, advancing at each new multiplication one term to the right in the first series, and $n+1$ terms to the left in the second series, until a term is reached in the first series, the exponent of x in which is equal to, or greater than s. The sum of the several products thus obtained will be the value of N. We have therefore

$$N=\frac{h(h+1)(h+2).....h+s-1}{1.2.3 \quad ..... \quad s}$$
$$-\frac{h}{1} \times \frac{h(h+1)(h+2).....h+s-n-2}{1.2.3 \quad ..... \quad s-n-1}$$
$$+\frac{h(h-1)}{1.2} \times \frac{h(h+1)(h+2).....h+s-2n-3}{1.2.3 \quad ..... \quad s-2n-2}$$
$$-\&c.$$

The series now found for N may be changed into another, having a more elegant form, by reducing all the terms to others having the common denominator $1.2.3.....h-1$. This will be accomplished by leaving out of the numerator and denominator of the first term all the numbers after $h-1$ to s, (including s), when s is greater than $h-1$, or by inserting the numbers between s and $h-1$ (the last included), when $s \angle h-1$; by leaving out of the numerator and denominator of the second term all the numbers from $h-1$ to $s-n$, or by inserting those numbers; and so on with the other terms. If we then make the common denominator $1.2.3...h-1=k$, we shall have

$$N=\frac{1}{k}(s+1)(s+2)(s+3).....(s+h-1)$$
$$-\frac{h}{k}(s-n)(s-n+1).....(s-n+h-2)$$
$$+\frac{h(h-1)}{1.2k}(s-2n-1)(s-2n).....(s-2n+h-3)$$
$$-\&c.$$

to be continued till the last factor of one of the terms becomes 0 or negative. If we also make

$$s+h-1=f$$
$$s-n+h-2=f-(n+1)=f'$$
$$s-2n+h-3=f-2(n+1)=f''$$
$$s-3n+h-4=f-3(n+1)=f'''$$
$$\&c.$$

and write the factors in each of the terms in the reverse order, the above value of N will become

$$N=+f(f-1)(f-2).....(f-h+2)\frac{1}{k}$$
$$-f'(f'-1)(f'-2).....(f'-h+2)\frac{h}{k}$$
$$+f''(f''-1)(f''-2).....(f''-h+2)\frac{h(h-1)}{1.2k}$$
$$-f'''(f'''-1)(f'''-2).....(f'''-h+2)\frac{h(h-1)(h-2)}{1.2.3k}$$
$$+\&c.$$

21. As an example of the application of this formula, let Probability it be required to assign the probability of throwing the point 16 with 4 common dice. (Simpson, p. 53.)

A die having no face marked 0, it is necessary, in order to adopt the formula to this case, to suppose the number of points on each face to be diminished by unit, which is equivalent to supposing $s-h$ to be substituted for s. The numbers are then 0, 1, 2, 3, 4, 5, and we have $n=5$, $h=4$, and $s=(16-4)=12$. Hence

$$f=s+h-1=15$$
$$f'=f-(n+1)=9$$
$$f''=f-2(n+1)=3$$
$$f'''=f-3(n+1)=-3,$$

and $k=1.2.3$. Substituting these values in the formula, we find

$$N=15.14.13\times\frac{1}{6}(=+455)$$
$$-9.8.7\times\frac{4}{6}(=-336)$$
$$+3.2.1\times\frac{4.3}{1.2.6}(=+6)$$

or N=125. Now the probability of the event is $N \div (n+1)^h$; and in the present case $(n+1)^h=6^4=1296$; consequently the probability required, namely that of throwing the point 16 with 4 dice, is $\frac{125}{1296}$.

22. In the numerical solution of questions of this sort, it sometimes happens that the labour may be abridged by computing the probability of throwing a different point from that which is proposed, but which has the same number of chances in its favour. For example, let it be proposed to determine the probability that in throwing 10 dice the sum of the points will be 50. In this case, the smallest number of points that can possibly be thrown is 10, and the greatest 60; and the chances in favour of throwing 10 and of throwing 60 are obviously equal. The probability of throwing any given number of points above 10 is also evidently the same as that of throwing the number which is as much under 60; and consequently the probability of throwing 50 is the same as the probability of throwing 20, these numbers being at equal distances from the extremes. Now to find the probability of throwing 20 with 10 dice, or, which is the same, the probability that in 10 successive drawings from an urn containing 6 balls, marked with the numbers 0, 1, 2, 3, 4, 5, the sum of the numbers drawn will be 10, we have $h=10$, $n=5$, $s=10$; whence $f=19$, $f'=13$, $f''=7$, f''' negative, and $k=1.2...9$. Substituting these numbers in the series for N, and observing that since $f''-h+2=-1$, the third term becomes negative, we have

$$N=\frac{19.18.17.16.15.14.13.12.11}{1.2.3.4.5.6.7.8.9}(=92378)$$
$$-\frac{13.12.11.10.9.8.7.6.5}{1.2.3.4.5.6.7.8.9}(=-7150),$$

and consequently N=85228. Dividing this by $(n+1)^h=6^{10}=60466176$, the probability of throwing 20, or of throwing 50, with 10 dice is found $=\frac{85228}{60466176}$, or between $\frac{1}{709}$ and $\frac{1}{710}$.

23. The probability that the whole number of points drawn in h trials will *not exceed* s is found by substituting for s the different values 0, 1, 2.....s in the series for N, and taking the sum of the results. This labour, however, may be avoided by means of a property of the figurate numbers. It is well known that the sum of the series of numbers obtained by giving n every value from $n=1$ to $n=v$ (v being any number whatever) in the formula

$$\frac{n(n+1)(n+2)\ldots\ldots(n+u)}{1\cdot 2\cdot 3\ \ldots\ldots\ u+1}$$

is expressed by this other formula

$$\frac{v(v+1)(v+2)\ldots\ldots(v+u)(v+u+1)}{1\cdot 2\cdot 3\ \ldots\ldots(u+1)(u+2)};$$

or, which is the same thing, that the sum of the series obtained by giving x successively every value from $x=1+u$ to $x=1+u+v$ in the formula

$$\frac{x(x-1)(x-2)\ldots\ldots(x-u)}{1.2.3\qquad\qquad u+1}$$

is expressed by this other formula

$$\frac{(x+1)x(x-1)\ldots\ldots x-u}{1.2.3\ldots\ldots\ldots u+2},$$

in which $x=1+u+v$.

Comparing the different terms of the series for N (20) with these last formulæ, it will be evident, that on giving s every value successively, from 0 to s in the value of f, and denoting by N′ the sum of all the results, we shall have

$$N'=+\frac{(f+1)f(f-1)(f-2)\ldots\underline{(f-h+2)}}{1.2.3.4\quad\ldots\quad h}$$
$$-\frac{(f'+1)f'(f'-1)(f'-2)\ldots\underline{(f'-h+2)}}{1.2.3.4\quad\ldots\quad h}\times h$$
$$+\frac{(f''+1)f''(f''-1)(f''-2)\ldots\underline{(f''-h+2)}}{1.2.3.4\quad\ldots\quad h}\times\frac{h(h-1)}{1.2}$$
$$-\&c.$$

for the probability that the number of points thrown will not be greater than s.

As an example, let $h=10$, $s=5$, $n=5$; we have then $f=s+h-1=14$, $f'=f-(n+1)=8$, whence $f'-h+2=0$, and consequently the second term vanishes. Hence

$$N'=\frac{15.14.13.12.11.10.9.8.7.6}{1.2.3.4.5.6.7.8.9.10}=3003.$$

The probability, therefore, of the sum of the numbers drawn in 10 drawings not exceeding 5, is $3003\div(6)^{10}$, or $\frac{3003}{60466176}$. And this is also the probability that in throwing 10 common dice the sum of the points does not exceed 16. (Simpson, p. 60.)

24. In the preceding questions the number of trials, denoted by h, has been supposed to be given; and the object, in every case, has been to determine the value of a given term, or of a given number of terms of the series produced by the development of the binomial $(p+q)^h$. But there is a numerous class of questions in respect of which the exponent h is unknown, and is required to be determined from the condition that an assigned term, or the sum of a certain number of assigned terms of the development, must have a given value. For example, let it be proposed to determine how often a common die must be thrown in order to give the probability of ace turning up *once at least*, equal to a given fraction u. Here the probability of throwing ace in any throw being $\frac{1}{6}$, we have $p=\frac{1}{6}$, and $q=\frac{5}{6}$. Now, as every term of the development of $(p+q)^h$, excepting the last, gives a combination in which ace occurs once or oftener, the question requires a value to be found for h, such, that the sum of the first h terms of that development, shall be equal to u. This may be done, in general, by the common methods of trial and error; but in the present case, the last term being the only one not included among those which contain a chance of throwing ace, it is evident that it is only necessary to find the last term alone in order to have the probability of *not* throwing ace in h trials, which by the question is $1-u$. The last term of the development is q^h; therefore we must have the equation $q^h=1-u$; whence $h\log q=\log(1-u)$ and $h=\log(1-u)\div\log q$. Let $1-u=\frac{\beta}{\gamma}$ and $q=\frac{b}{c}$, we shall then have $\log(1-u)=$ Probability $\log\beta-\log\gamma$, and $\log q=\log b-\log c$; whence

$$h=\frac{\log\beta-\log\gamma}{\log b-\log c}.$$

Substituting in this general formula the particular numbers given in the question, namely $b=5$, $c=6$; and supposing $u=\frac{1}{2}$, and consequently $\beta=1$, $\gamma=2$, we have $h=\frac{\log 2}{\log 6-\log 5}$; whence, by computing from the logarithmic tables, $h=3{\cdot}8$. From this it follows, that in four trials the probability of throwing ace once at least, is greater than the probability of not throwing it at all.

If the question had been to determine in how many throws with two dice one may undertake, on an equality of chance, to throw aces at least once, we should have had $p=\frac{1}{36}$, $q=\frac{35}{36}$, and consequently $b=35$, and $c=36$. Substituting these numbers in the general formula, and observing, that in this case also $\beta=1$, $\gamma=2$, we get $h=\frac{\log 2}{\log 36-\log 35}=24{\cdot}6$.

The probability of not throwing aces once is therefore greater than the opposite probability or that of throwing aces once or oftener, when the number of throws is 24, but less when the number is 25.

These two questions are celebrated in the early history of the theory of Probability, from the circumstance that the Chevalier de Méré, by whom they were proposed to Pascal, declared the two results above stated to be inconsistent with each other, and thence took occasion to question the accuracy of the theory of combinations by means of which they had been obtained. He reasoned thus: Since the probability of throwing ace with one die is $\frac{1}{6}$, and that of throwing aces with two dice $\frac{1}{6}$ of $\frac{1}{6}=\frac{1}{36}$; therefore, if there be a given probability in favour of throwing ace in four throws with one die, there must likewise be the same probability of throwing aces with two dice in $6\times 4=24$ throws; in other words, the chances in favour of an event E in a single trial, being six times more numerous than those in favour of F, there will be as many chances in favour of F in six trials as there are in favour of E in one. The error consists in supposing that the number of trials must increase or diminish exactly in the inverse ratio of the probability of obtaining the proposed point.[1]

25. The general question may be enunciated as follows: Let $p=$the probability an event E will happen, q the probability it will fail; how many trials are required to give a probability $=u$ that E will happen k times.

Let $x=$the number required. Taking the sum of all the terms of the development of $(p+q)^x$ in which the exponent of p is less than k, we shall have the probability that the event does *not* happen k times in x trials. This sum must consequently be made equal to $1-u$; therefore, beginning the last term, and writing the terms in the reverse order, we have the equation

$$q^x+x\,q^{x-1}p+\frac{x\,(x-1)}{1\ldots.2}q^{x-2}\,p^2\ldots\ldots$$
$$+\frac{x\,(x-1)\ldots(x-k+2)}{1\ .\ 2\ldots\ldots\ldots(k-1)}q^{x-k+1}\,p^{k-1}=1-u.$$

Let $p=e\,q$, and this equation becomes

$$q^x\left\{1+x\,e+\frac{x\,(x-1)}{1\ .\ 2}\,e^2\ldots\ldots+\frac{x\,(x-1)\ldots\ldots(x-k+2)}{1\ .\ 2\ldots\ldots\ldots(k-1)}\,e^{k-1}\right\}$$
$$=1-u$$

from which the value of x may be found by the ordinary methods of converging series.

If $p=q=\frac{1}{2}$, then $e=1$; and if we also suppose $u=\frac{1}{2}$, and consequently $1-u=\frac{1}{2}$, the equation will become

[1] Pascal, *Œuvres*, tom. iv. p. 367; Lacroix, *Elémentaire*, p. 36.

Probability $1+x+\frac{x\,(x-1)}{1\,.\,2}\ldots+\frac{x\,(x-1)\ldots x-k+2}{1\,.\,2\ldots\ldots k-1}=\frac{1}{2}\,(1+1)^x$.

But the first side of this equation is the expansion of $(1\times 1)^x$ continued to k terms; therefore, since the sum of the first k terms is equal to one-half of the whole series, and the terms of the first half of the series are the same as those of the last, it follows that the whole number of terms must be $2k$. But the whole number of terms in the expansion of $(1+1)^x$ is $x+1$; therefore $2k=x+1$, and $x=2k-1$. Suppose $k=10$, then $x=19$; hence in tossing a shilling it is an even bet that head will turn up 10 times in 19 throws.

SECT. III. OF THE PROBABILITY OF EVENTS DEPENDING ON A REPETITION OF TRIALS, OR COMPOUNDED OF ANY NUMBER OF SIMPLE EVENTS, THE CHANCES IN RESPECT OF WHICH ARE KNOWN *A PRIORI*, AND VARY IN THE DIFFERENT TRIALS.

26. Let us suppose the trials to consist in drawing balls from an urn containing a white balls, and b black balls, and that when a ball is extracted it is not returned to the urn. Make $a+b=c$, and let the extraction of a white ball be the event W, and that of a black ball the event B. At the first trial the probability of W is $\frac{a}{c}$ (4), and that of B, $\frac{b}{c}$. But at the second trial, the number of balls in the urn is diminished by 1; and the probability of drawing a white ball at the second trial is therefore not the same as it was in the first, but is influenced by the event which has already taken place. If W happened at the first trial, the number of white balls remaining in the urn is then $a-1$; the number of black is b, and the number of both colours $c-1$. The probability of W at the next trial is therefore $\frac{a-1}{c-1}$, and that of B is $\frac{b}{c-1}$. In like manner, if B happened at the first trial, the probability of W at the second is $\frac{a}{c-1}$, and that of B is $\frac{b-1}{c-1}$. Hence (7) the different combinations which can arise from two trials are the following:

WW, WB, BW, BB,

the probabilities of which are respectively,

$$\frac{a(a-1)}{c(c-1)},\quad \frac{ab}{c(c-1)},\quad \frac{ba}{c(c-1)},\quad \frac{b(b-1)}{c(c-1)}.$$

Now if we neglect the order of succession in the two cases in which W and B are combined, the probability of the compound event which consists of the extraction of a ball of each colour in the two trials, is $\frac{2ab}{c(c-1)}$, and the probabilities of the three possible combinations are respectively:—

$$\frac{a(a-1)}{c(c-1)},\quad \frac{2ab}{c(c-1)},\quad \frac{b(b-1)}{c(c-1)}.$$

Comparing these with the probabilities of the same combinations when the chances are constant, or the ball is returned to the urn after each drawing, namely

$$\frac{a^2}{c^2},\quad \frac{2ab}{c^2},\quad \frac{b^2}{c^2},$$

the analogy of the two cases is obvious.

After two balls have been drawn, the whole number remaining in the urn is $c-2$; but the number of each colour depends on the two events that have already occurred. If two white balls have been drawn, the probability of drawing a white ball at the next trial will be $\frac{a-2}{c-2}$; but we have just seen that the probability of WW is $\frac{a(a-1)}{c(c-1)}$; therefore (7) the probability of WWW is $\frac{a(a-1)(a-2)}{c(c-1)(c-2)}$. The probability of drawing a black ball after two white have been drawn is $\frac{b}{c-2}$ (for there are now $c-2$ balls in the urn, of which b are white); therefore the probability of WWB is $\frac{a(a-1)b}{c(c-1)(c-2)}$. On forming in this manner all the different possible combinations which can result from three trials, we find

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$$\text{WWW, probability, } = \frac{a(a-1)(a-2)}{c(c-1)(c-2)},$$
$$\text{WWB, } \ldots\ldots = \frac{a(a-1)b}{c(c-1)(c-2)},$$
$$\text{WBW, } \ldots\ldots = \frac{ab(a-1)}{c(c-1)(c-2)},$$
$$\text{BWW, } \ldots\ldots = \frac{ba(a-1)}{c(c-1)(c-2)},$$
$$\text{BBW, } \ldots\ldots = \frac{b(b-1)a}{c(c-1)(c-2)},$$
$$\text{BWB, } \ldots\ldots = \frac{ba(b-1)}{c(c-1)(c-2)},$$
$$\text{WBB, } \ldots\ldots = \frac{ab(b-1)}{c(c-1)(c-2)},$$
$$\text{BBB, } \ldots\ldots = \frac{b(b-1)(b-2)}{c(c-1)(c-2)}.$$

If we disregard the order of succession in those combinations into which W and B both enter, and consider the occurrence of W twice and B once as the same compound event; and also the occurrence of W once and B twice as the same compound event, in whatever order they occur, the probability of the former will be $\frac{3a(a-1)b}{c(c-1)(c-2)}$, and of the latter $\frac{3ab(b-1)}{c(c-1)(c-2)}$.

27. In general, if $m'+n'$ balls have been drawn, of which m' have been found to be white and n' black, the number of white balls in the urn will now be $a-m'$, the number of black $b-n'$, and the whole number of both colours $c-m'-n'$. Hence the probability of drawing a white ball in the next trial will be $\frac{a-m}{c-m'-n'}$; and that of drawing a black ball $\frac{b-n'}{c-m'-n'}$. Now if in these two fractions we substitute successively for m' and n' all the different numbers from 0 to $m-1$ and $n-1$ respectively, the product of the $m+n$ numbers thus obtained will (7) be the probability of drawing m white balls and n black in an assigned order, in $m+n$ trials. Let this probability be denoted by K, and we shall have

$$\text{K}=\frac{a(a-1)(a-2)\ldots\ldots(a-m+1)\times b(b-1)(b-2)\ldots\ldots(b-n+1)}{c(c-1)(c-2)\ldots\ldots(c-m-n+1)},$$

whatever the given order may be. Hence, if we denote by P the probability of m white balls and n black being drawn in any order whatever, in h trials, we shall have $\text{P}=\text{UK}$, where, as in (12), $\text{U}=\frac{1\,.\,2\,.\,3\ldots\ldots h}{1\,.\,2\,.\,3\ldots\ldots m\times 1\,.\,2\,.\,3\ldots\ldots n}$ the co-efficient of that term of the binomial $(p+q)^h$ which has for its argument $p^m\,q^n$; this co-efficient expressing all the different arrangements which can be formed of m things of one kind, and n things of another.

28. When the urn is supposed to contain balls of more than two different colours, the probability of any proposed number of each colour being drawn in a given number of trials is found with the same facility. Suppose it to contain a_1 of the first colour, a_2 of the second, a_3 of the third, and so on, and let $a_1+a_2+a_3$ &c.$=c$; then the probability that

Probability in $m+n+r+$&c.$=h$ trials, there will be drawn m of the first colour, n of the second, r of the third, &c. is

$$U' \times a_1(a_1-1)(a_1-2).....(a_1-m+1) \times a_2(a_2-1)(a_2-2).....(a_2-n+1) \times a_3(a_3-1)(a_3-2).....(a_3-r+1) \times a_4(a_4-1)(a_4-2).....(a_4-s+1) \times \text{&c.} \div c(c-1)(c-2).....(c-h+1)$$

where, as in (15),

$$U = \frac{1.2.3.....h}{1.2.3.....m \times 1.2.3.....n \times 1.2.3.....r \times \text{&c.}}.$$

29. The following examples will shew the use of the preceding formulæ.

Suppose a bag to contain 16 balls, of which 8 are white and 8 black, what is the probability that in drawing 8 balls from the bag the whole of them will be white?

Applying the formula (27) to the solution of this question, we have $a=8$, $b=8$, $c=16$, $m=8$, $n=0$, and as the probability required is that of drawing white balls only, b cannot enter into any of the factors of the numerator; hence

$$K=\frac{8.7.6.5.4.3.2.1}{16.15.14.13.12.11.10.9}=\frac{1}{12870};$$

and since $m=h$, $U=1$, the probability sought, is therefore $\frac{1}{12870}$.

Let there be a heap of 20 cards, wherein are 7 diamonds, 6 hearts, 4 spades, and 3 clubs; required the probability that in drawing 8 of them at a venture there shall come out 3 diamonds and 2 hearts? (Simpson, p. 21.)

The probability required in this case being that of drawing 3 diamonds, 2 hearts, and 3 other cards which are neither diamonds nor hearts, the spades and clubs may be considered as forming one parcel, containing 7 cards. We have then in the formula (28) $a_1=7$, $a_2=6$, $a_3=7$, $c=20$; $m=3$, $n=2$, $r=3$, $h=8$; therefore

$$U'=\frac{1.2.3.4.5.6.7.8}{1.2.3 \times 1.2 \times 1.2.3}=560,$$

and the probability required becomes,

$$560 \times \frac{7.6.5 \times 6.5 \times 7.6.5}{20.19.18.17.16.15.14.13}=\frac{1225}{3978}.$$

The odds against the event are therefore 2753 to 1225, or nearly 9 to 4.

Let 4 cards be drawn from a pack of 52; what is the probability of drawing one of each sort?

In this case we have $a_1=13$, $a_2=13$, $a_3=13$, $a_4=13$, $c=52$; also $m=1$, $n=1$, $r=1$, $s=1$, $h=4$, whence $U'=\frac{1.2.3.4}{1.1.1.1}=24$, and the probability required becomes, on substituting these numbers in the formula (28),

$$24 \times \frac{13.13.13.13}{52.51.50.49}=\frac{2197}{20825}=\frac{1}{9} \text{ nearly.}$$

The odds against this event are nearly 8 to 1.

30. The following question, proposed by Huygens, and solved by Demoivre and Bernoulli (*Ars Conjectandi*, p. 59), belongs to the class of problems now under consideration.

An urn contains 12 balls, of which 4 are white and 8 black. Three gamesters A, B, and C agree that the first who, blindfold, shall draw a white ball shall be the winner of the stakes. They also agree that A shall draw first, B second, C third, A fourth, and so on; and the balls drawn are not replaced in the urn. It is proposed to find their respective probabilities of winning.

Here the play terminates as soon as a white ball is drawn, and it must therefore terminate with the 9th trial, if not sooner, inasmuch as, after 8 black balls have been drawn, the urn will contain only white balls, and the probability of drawing a white ball at the next trial will become certainty. The question will therefore be solved, if we determine the probabilities of the play ending with the 1st, 2d, 3d, 4th, &c. games respectively, and take the sum of the probabilities of its ending with the 1st, 4th, and 7th, for the probability of A's winning; the sum of the probabilities of its ending with the 2d, 5th, and 8th, for the probability of B's winning; and the sum of the probabilities of its ending with the 3d, 6th, and 9th, for the probability of C's winning. Probability

For the sake of rendering the solution more general, let a be the number of white balls in the urn, b the number of black, and let $a+b=c$. The probability of drawing a white ball at the first trial, or of the play ending with the first trial, is then $\frac{a}{c}$.

The probability of the play ending with the second trial is compounded of the probability of a black ball being drawn at the first trial, and a white at the second; and the probability of both events (26) is $\frac{ba}{c(c-1)}$.

The probability of the play ending with the third trial is compounded of three separate probabilities, namely, that a black ball will be drawn at the first trial; that a black ball will be drawn at the second; that a white ball will be drawn at the third;—and the probability of the concourse of these events (26) is $\frac{b(b-1)a}{c(c-1)(c-2)}$.

In general the probability of a black ball being drawn in $x-1$ trials successively, and a white ball at the xth is $\frac{b(b-1)(b-2).....(b-x+2)a}{c(c-1)(c-2).....(c-x+1}$. Substituting for a, b, and c in this formula the numbers proposed by Huygens, we obtain in respect of the 1st, 4th, and 7th trials, or the probability in favour of A,

$$\frac{4}{12}+\frac{8.7.6}{12.11.10}.\frac{4}{9}+\frac{8.7.6.5.4.3}{12.11.10.9.8.7}.\frac{4}{6}=\frac{77}{165};$$

in respect of the 2d, 5th, and 8th trials, or the probability in favour of B,

$$\frac{8}{12}.\frac{4}{11}+\frac{8.7.6.5}{12.11.10.9}.\frac{4}{8}+\frac{8.7.6.5.4.3.2}{12.11.10.9.8.7.6}.\frac{4}{5}=\frac{53}{165},$$

and in respect of the 3d, 6th, and 9th trials, or the probability in favour of C,

$$\frac{8.7}{12.11}.\frac{4}{10}+\frac{8.7.6.5.4}{12.11.10.9.8}.\frac{4}{7}+\frac{8.7.6.5.4.3.2.1}{12.11.10.9.8.7.6.5}.\frac{4}{4}=\frac{35}{165}.$$

The chances in favour of A, B, and C, are therefore proportional to the numbers 77, 53, 35, respectively.

If the condition of the play had been that the ball was to be returned to the urn after each trial, the chances in favour of the three gamesters would have been easily found by the formula (12) to be respectively as the numbers 9, 6, and 4.

SECT. IV. OF MATHEMATICAL AND MORAL EXPECTATION.

31. In the theory of probability, the term *expectation* is used to denote the product found by multiplying the value of a casual benefit into the probability of the event on which it is contingent taking place. But the value of a benefit may be estimated either with respect to its absolute amount, or to the amount of relative advantage it affords the individual who receives it. This consideration has led to a distinction between mathematical and moral expectation. When we place the circumstances of the individual entirely out of consideration, and have regard merely to the abstract or absolute value of the benefit, the product of its amount by the probability of obtaining it is the *mathematical expec-*

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tation of the individual; but when a relative value is assigned to the benefit, the product of this relative value by the probability of obtaining it is called the *moral expectation*, because it is estimated by certain moral considerations respecting the circumstances or fortune of the individual in whose favour the expectation exists, on the principle that a sum of money which may be relatively of very little importance to a man in possession of a large fortune may be of great importance to another who is less favourably circumstanced. We shall first consider the *mathematical expectation*.

32. Suppose A and B to engage in play; let p be the probability of A's winning a game, q the probability of B's winning it, and s a sum of money staked on the issue of the game. By the definition, the mathematical expectation of A is ps, and that of B is qs. Now if we suppose these expectations to be purchased by A and B, the sums they ought respectively to pay for them, or in other words to stake on the issue of the game, must be proportional to their respective expectations, in order that they may play on equal terms. Let therefore a be the sum staked by A, and b the sum staked by B, we have then $ps : qs :: a : b$, and consequently $pb=qa$. Now suppose $a+b=s$, or that the sum played for is the amount of the stakes; then, since b is the sum A expects to gain, and p is the probability of his gaining it, pb is the mathematical value of A's expectation of gain. In like manner qa is the mathematical value of B's expectation of gain. Hence it follows, that when the sum staked by each is proportional to his probability of winning, the mathematical expectations of the two players are equal; so that after the stakes have been placed, and before the event is decided, they might exchange places without advantage or disadvantage to either. It follows likewise, that since the sum which the one must gain is just that which the other must lose, the product qa, which is B's expectation of gain, may be regarded as A's expectation of loss; or (if taken with a negative sign) as part of A's whole expectation, which then becomes $pb-qa$. But $pb-qa=0$; whence the condition of A before the event is decided is not altered by the circumstance of his having staked on the issue of the play.

33. This conclusion at first sight appears paradoxical; for it is certain, that after the stakes are placed, A must either gain the sum b or lose a, and therefore his fortune will of necessity either be increased by the gain of his adversary's stake, or diminished by the loss of his own. The explanation depends on theorems which will afterwards be demonstrated relative to the repetition of trials, from which it results, that though in a single trial the player must either lose or gain, yet on multiplying sufficiently the number of games, a probability will at length be obtained, approaching as nearly to certainty as we please, that the sum gained or lost in the long run will not exceed a certain given fraction (which may be as small as we please) of the whole sum staked, provided the play is undertaken on terms of mathematical equality. But this indefinite repetition of the hazard is practically impossible; and innumerable cases may easily be imagined, in which an individual will be guided by other considerations than the mere mathematical value of the expectation in undertaking or declining a risk. A person of moderate fortune would scarcely be persuaded to risk L.500 for the expectation of gaining L.5, though the chances might be 100 to 1 in favour of the event which would produce that sum; but numbers would be found willing enough to pay L.5 for the expectation of gaining L.500, the chances being 100 to 1 against them. In both cases, however, the expectation would be purchased at its real abstract value. According to the formula of mathematical expectation, the man whose sole fortune consists of a lottery ticket which has an equal chance of turning up a prize of L.20,000 or a blank, is in an equally advantageous position as he who is in possession of L.10,000; yet no man of ordinary prudence, if offered his choice of the two states, would hesitate as to which he ought to give the preference. Common sense will prevent a man from risking a sum, the loss of which would be attended with great privations, even when, mathematically speaking, the chances are considerably in his favour. It is also obvious that two individuals whose fortunes are very unequal cannot engage in play with the same advantage, although the chances in favour of each, in respect of a single game, are precisely the same. The one who has a large fortune can repeat the hazard so often as to obtain a probability almost equal to certainty that his loss will not amount to any given sum; whereas the other, who cannot continue the play in case of loss, runs the risk of being ruined. It is thus evident, that in a multitude of cases the abstract theory of probability is not alone sufficient to give the value of an expectation, and that in dealing with contingent events, an individual must be guided to a certain extent by considerations of relative advantage.

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34. Various hypotheses have been imagined for the purpose of reducing such relative or moral considerations to accurate calculation; but that which appears the most natural, and applicable to the greatest number of cases, consists in supposing the relative value of any infinitely small sum to be directly proportional to its absolute value, and inversely as the fortune of the individual who has an expectation of receiving it. This principle was first proposed by Daniel Bernoulli in the *Petersburg Commentaries* (vol. v.), and is there applied by him to the solution of a number of questions of great practical interest.

Let x be the absolute value of the capital, or, as it is denominated by Laplace, the physical fortune, of an individual; then, according to the hypothesis of Bernoulli, the moral advantage which he derives from an infinitely small increment of fortune $=dx$, is measured by the expression $c\frac{dx}{x}$, c being a constant to be determined by the nature of the question. Now, if we suppose the physical fortune to arise from the accumulation of the elements dx, and denote by y the relative or *moral value* of the fortune, of which the absolute or physical value is x, we shall have

$$y=\int c\frac{dx}{x}=c \text{ log. } x+\text{constant.}$$

To determine the constant, we may suppose $y=o$, when x has a given value $=a$; this gives $o=c$ log. $a+$constant, whence $y=c$ (log. x—log. a), or $y=c$ log. $\frac{x}{a}$; and it is to be observed, that those values of x and y can never become negative, for as Bernoulli has remarked, it is only the person who is dying of hunger that can be said to possess absolutely nothing. In every other circumstance the mere possession of existence may be accounted a moral advantage, to which, however, it would be absurd to attempt to assign a numerical value.

35. From the above formula, it is easy to deduce a numerical expression for the value of a moral expectation. Let a be the original fortune of the individual, and α, β, γ, &c. sums to be received on the occurrence of certain contingent events, E, F, G, &c. This being supposed, if the event E happens, the absolute fortune of the individual becomes $a+\alpha$, and its relative value, therefore, according to the formula, is c log. $\frac{a+\alpha}{a}$. If F happens, his absolute fortune becomes $a+\beta$, to which the corresponding relative value is c log. $\frac{a+\beta}{a}$; and so on. Now, let the probabilities of the events E, F, G, &c. be respectively p, q, r, &c. (assuming $p+q+r+$ &c.$=1$, so that one or other of the events will necessarily happen), and let Y represent the relative fortune of the individual arising from his expectation, then, since the

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value of a benefit in expectation is equal to the amount of the benefit multiplied by the probability of obtaining it, we have

$$Y=c\left\{p\log.\frac{a+\alpha}{a}+q\log.\frac{a+\beta}{a}+r\log.\frac{a+\gamma}{a}+\&c.\right\}$$

Let also X denote the absolute value of Y; then, by the formula, we have $Y=c\log.\frac{X}{a}$. On comparing these two values of Y, we get

$$\log.\frac{X}{a}=p\log.\frac{a+\alpha}{a}+q\log.\frac{a+\beta}{a}+r\log.\frac{a+\gamma}{a}+\&c.;$$

and on passing to numbers,

$$\frac{X}{a}=\frac{(a+\alpha)^p(a+\beta)^q(a+\gamma)^r,\&c.}{a^{p+q+r+\&c.}},$$

therefore, since $p+q+r+\&c.=1$,

$$X=(a+\alpha)^p(a+\beta)^q(a+\gamma)^r,\&c.$$

In this expression X denotes the absolute value of the original fortune and of the expectation added together; if, therefore, we deduct a from X, the difference will be the value of the expectation, or the sum which, if it were to be received certainly, would procure the individual the same relative advantage as his expectation.

36. If the sums α, β, γ, &c. are supposed to be very small in comparison of a, so that quantities of the order $\left(\frac{\alpha}{a}\right)^2$ may be neglected, the preceding equation becomes

$$X=a^{p+q+r+\&c.}+a^{p+q+r\&c.-1}\left\{p\alpha+q\beta+r\gamma+\&c.\right\}$$

whence, since $p+q+r+\&c.=1$,

$$X=a+p\alpha+q\beta+r\gamma+\&c.$$

Deducting from this the original fortune a, the remainder $p\alpha+q\beta+r\gamma+\&c.$ is the value of the expectation, or the sum equivalent to the moral advantage. But the value of the mathematical expectation of the benefits α, β, γ, &c. of which the probabilities are respectively p, q, r, &c. is also $p\alpha+q\beta+r\gamma+\&c.$ (31), therefore, when the contingent benefits are very small in comparison of the original fortune, the moral advantage and the mathematical expectation are sensibly the same.

37. From the formula $X=(a+\alpha)^p(a+\beta)^q(a+\gamma)^r$ &c. Bernoulli deduces the consequence that gambling or betting is attended with a moral disadvantage, even when the chances of gain or loss, mathematically speaking, are perfectly equal. To shew this, he proposes the following question. A, whose fortune is 100 crowns, bets 50 crowns with B, on the issue of an event of which the probability is $\frac{1}{2}$, on these terms: if the event happens, A is to receive from B 50 crowns; if it fails, he is to pay B 50 crowns; what is the relative value of A's fortune, after undertaking the bet, and before the event is decided? In this case, we have $a=100$, $\alpha=50$, $\beta=-50$, $\gamma=0$; also $p=\frac{1}{2}$, $q=\frac{1}{2}$, $r=0$; and the formula (35) becomes

$$X=(100+50)^{\frac{1}{2}}\times(100-50)^{\frac{1}{2}},$$

whence $X=\sqrt{150\times50}=87$; and, consequently, the condition of A is worse by 13 crowns than it was before he hazarded the bet. The moral disadvantage is therefore equivalent to this sum, though the terms of the play, according to the mathematical theory, are equal.

38. The conclusion arrived at in this particular case is easily shewn to be universally true. Let a be the capital of the player, p his probability of winning, q his probability of losing, and s the sum at stake. In order that he may play on terms of mathematical equality, the part of the stakes contributed by himself, or the sum which he can lose, must be ps (32), and the part contributed by his adversary, or that which he may gain, must be qs. The equation in (35) therefore becomes

$$X=(a+qs)^p\times(a-ps)^q,$$

and if it can be shewn that this value of X is less than a, it will follow that his condition is rendered worse in consequence of having staked on the game. Now, dividing by a, and taking the logarithm of both sides of the equation, we get $\log.\frac{X}{a}=p\log.\left(1+\frac{qs}{a}\right)+q\log.\left(1-\frac{ps}{a}\right)$, the differential of which (making s variable) is

$$d\log.\frac{X}{a}=pqds\left(\frac{1}{1+\frac{qs}{a}}-\frac{1}{1-\frac{ps}{a}}\right).$$

But the second side of this equation is evidently negative; therefore $d\log.X\div a$ is negative; consequently the logarithm of $X\div a$ is negative, and X must be less than a. In all cases, therefore, the bet, if on even terms, produces a moral disadvantage.

39. Another consequence deduced by Bernoulli from this theory of moral expectation, is, that when property of any kind is exposed to a risk or hazard, it is more advantageous to expose it in parts to several risks independent of each other, than to expose the whole at once to a single risk, although the probability of loss be in both cases precisely the same. To prove this, he takes the following example. A merchant has a capital of L.4000, besides goods of the value of L.8000, which must be transported by sea. The probability of the loss of a vessel in the voyage being $\frac{1}{10}$, let it be proposed to find the value of the moral expectation of the merchant in the case of the goods being embarked in a single vessel, and also in the case of one half being embarked in one vessel and the other half in another. Supposing the merchandise embarked in one ship, the absolute fortune of the merchant will be increased to L.12,000 in the event of the safe arrival of the ship, and will be reduced to L.4000 in the event of its being lost. The probability of the first of these events is $\frac{9}{10}$, and of the second $\frac{1}{10}$; therefore his absolute fortune becomes, in virtue of his expectation,

$$X=(12{,}000)^{\frac{9}{10}}\times(4000)^{\frac{1}{10}},$$

whence X=10751. Deducting his other capital, L.4000, there remains L.6751 for the value of the moral expectation in respect of the venture.

Let us next suppose the merchandise embarked in equal parts in two ships. In this case there are three compound events to be considered, 1st, Both vessels may arrive in safety; the probability of which is $\frac{9}{10}\times\frac{9}{10}=\frac{81}{100}$. 2d, One may arrive in safety and the other be lost; the probability of which, as it may happen in two ways, (11) is $2\times\frac{9}{10}\times\frac{1}{10}=\frac{18}{100}$. 3d, Both may be lost; the probability of which is $\frac{1}{10}\times\frac{1}{10}=\frac{1}{100}$. If the first of these events happen, the capital of the merchant will become L.4000+L.8000=L.12,000; if the second happen it will be L.4000+L.4000=L.8000; and if the third happen it will be only L.4000. With these numbers the formula becomes

$$X=(12{,}000)^{\frac{81}{100}}\times(8000)^{\frac{18}{100}}\times(4000)^{\frac{1}{100}},$$

whence X=11033. Deducting his other capital, which was exposed to no risk, there remains L.7033 for the value of the moral expectation. This sum exceeds the former by L.282; and it is easily found by following the same process of reasoning, that in proportion as the risk is divided among a greater number of ships, the moral expectation is increased, and approaches its limit, which is the value of the mathematical expectation, or $\frac{9}{10}$ of L.8000=L.7200.

40. The theory of moral expectation enables us likewise to assign the circumstances in which it is advantageous or

Probability otherwise, to insure property against particular hazards. There are three principal questions to be considered in reference to this subject; 1. The amount of premium the insured may pay without disadvantage; 2. The ratio of his fortune to the value of the sum exposed to risk, in order that it may be advantageous to insure at a given premium; and 3. The capital which the insurer or underwriter ought to possess, in order that he may insure a given risk with probable advantage to himself, and safety to the insured.

Let s be the value of a cargo which a merchant embarks in a ship, p the probability of the safe arrival of the vessel, and a his capital independently of s. The mathematical value of the premium for insurance is qs; for, if we denote the premium by y, then y is the sum the insurer will gain if the vessel reaches its destination in safety, and $s-y$ is the sum he will lose if it does not; and by the theorem for the mathematical expectation $py=q(s-y)$; whence, since $p+q=1$, $y=qs$. If, therefore, the merchant insures the cargo, his absolute fortune becomes $a+s-qs=a+ps$; and if he does not insure, it is the value of X in the equation $X=(a+s)^p a^q$. Hence it will be advantageous or otherwise to insure according as $a+ps$ is greater or less than $(a+s)^p a^q$. Now the logarithm of the first of these expressions, or $\log(a+ps)$, is equivalent to the integral $\int \frac{pds}{a+ps}$; and the logarithm of the second, or $p\log(a+s)+q\log a$, is equivalent to $\int \frac{pds}{a+s}$; but since p is a proper fraction, $a+ps$ is less than $a+s$, and therefore the first integral is greater than the second. Consequently $a+ps$ is, in general, greater than $(a+s)^p a^q$, and the insurance is attended with advantage. Let us now assume $x=a+ps-(a+s)^p a^q$, and x will be the sum the merchant could afford to pay the insurer above the mathematical value of the risk without moral disadvantage. If he pays less than $qs+x$, his relative fortune is increased by insuring; and if he pays more he is a loser. In practice the premium may be considered as less than $qs+x$, but greater than qs; so that while the insured pays more than the mathematical value of the risk, he gains a moral advantage by the transaction.

To solve the second question, let e be the premium demanded for insuring the amount s; then, the other capital of the merchant being a, his fortune after being insured is $a+s-e$; while if he takes the risk on himself, its value becomes $(a+s)^p a^q$. If, therefore, the value of a be determined from the equation $a+s-e=(a+s)^p a^q$, we shall have the amount of capital he ought to possess in order that it may be *morally* a matter of indifference to him whether he insures or not. As an example, let the value of the merchandise, or s, be L.10,000, e=L.800, and $p=\frac{19}{20}$. The equation then becomes

$$a+9200=(a+10{,}000)^{\frac{19}{20}}a^{\frac{1}{20}};$$

whence a is found by approximation =5043. It follows, therefore, that unless his other capital amount to L.5043, it would be disadvantageous to neglect insuring, although the premium demanded exceed the mathematical value of the risk (which is $\frac{1}{20}\times$L.10,000=L.500) by L.300.

The third question, the amount of capital the underwriter ought to possess, is determined precisely in the same way. Let b be his capital. After accepting the risk of the sum s for the premium e, his capital will become $b+e$ in the case of the vessel arriving in safety, and $b-s+e$ in the case of its being lost. The formula of the moral expectation therefore becomes $X=(b+e)^p(b-s+e)^q$; and in order that there may be neither advantage nor disadvantage in undertaking the risk, this value of X must be equal to his original capital, b. Supposing, therefore, s, e, p, q, to have the same significations as above, the equation from which b is to be determined is $b=(b+800)^{\frac{19}{20}}(b-9200)^{\frac{1}{20}}$, whence b=14243. Unless, therefore, the capital of the insurer amounts to L.14,243, there would be a moral disadvantage in undertaking the risk of insuring a cargo worth L.10,000 for a premium of L.800; and it is easy to see, that if a smaller premium were demanded, the capital ought to be still greater. On making e=600, (which still exceeds the mathematical value of the risk), the value of b becomes L.29,878. Hence it follows, that a company possessing a large capital may not only with safety engage in speculations which might prove ruinous to another whose resources are more limited, but even derive from them a sure profit.[1]

41. The theory of moral expectation which we have now been considering had its origin in a problem proposed by Nicolas Bernoulli to Montmort, which, from its having been discussed at great length by Daniel Bernoulli in the *Petersburg Memoirs*, has been usually called the Petersburg problem. It is this; A and B play at heads and tails. A agrees to pay B 2 crowns if head turn up at the first throw; 4 crowns if it turn up at the second, and not before; 8 if it turn up at the third, and not before; and, in general, 2^n crowns if it turn up at the nth throw, and not before: required the value of B's expectation? Here the probability of head turning up at the first throw is $\frac{1}{2}$; the probability of its turning up at the second, and not at the first, is $\frac{1}{2}\times\frac{1}{2}=\frac{1}{4}$; the probability of its not turning up either at the first or second, and of its turning up at the third, $\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}=\frac{1}{8}$, and so on. Hence the probabilities of B receiving 2, 4, 8, 16.....2^n crowns are respectively $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}\ldots\ldots\frac{1}{2^n}$, consequently (31) the mathematical value of B's expectation is

$$\frac{1}{2}\times 2+\frac{1}{4}\times 4+\frac{1}{8}\times 8+\frac{1}{16}\times 16\ldots+\frac{1}{2^n}\times 2^n \text{ crowns.}$$

Now, as no limit can be assigned to n, inasmuch as it is possible that head may not turn up till after a very great, or any assignable number, of throws, this series, of which each term is unity, may go on for ever, and consequently the value of B's expectation becomes infinite. Yet it is obvious that no one would pay any considerable sum for the expectation. This disagreement between the dictates of common sense and the results of the mathematical theory, appeared to Montmort to involve a great paradox; although the question differs in this respect from no other question of chances in which the contingent benefit is very great, and the probability of receiving it very small. If the play could be repeated an infinite number of times, B might undertake to pay without disadvantage any sum, however large, for his expectation. A result, however, more in accordance with ordinary notions, is obtained from the principle of Bernoulli. Let a be the amount of B's fortune before the play begins, x the value of his expectation, or the sum he pays A in consideration of the agreement, and make $z=a-x$. If head turn up at the first throw, B's fortune becomes $z+2$; if at the second, and not before, $z+2^2$; if at the third, and not before, $z+2^3$; and so on. But the probabilities of these events being respectively $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}\ldots\ldots\frac{1}{2^n}$, the formula for the moral expectation becomes (35)

$$X=(z+2)^{\frac{1}{2}}(z+2^2)^{\frac{1}{4}}(z+2^3)^{\frac{1}{8}}\ldots.(z+2^n)^{\frac{1}{2^n}}.$$

Now the sum which B ought to pay will be determined by making the value of his moral expectation, after the bet, and before the play begins, equal to his previous fortune; we have therefore $a=X$, that is,

$$a=(z+2)^{\frac{1}{2}}(z+2^2)^{\frac{1}{4}}(z+2^3)^{\frac{1}{8}}\ldots\ldots$$

[1] See the *Commentarii Acad. Petropolitanæ*, tom. v.; Laplace, *Théorie des Prob.* p. 432; Lacroix, *Traité Elémentaire*, p. 132.

Probability The general term of this series being $(z+2^n)^{\frac{1}{2^n}} = 2^{\frac{n}{2^n}}\left(1+\frac{z}{2^n}\right)^{\frac{1}{2^n}}$, the equation may be put under the form

$$a=(2^{\frac{1}{2}}+2^{\frac{2}{4}}+2^{\frac{3}{8}}+2^{\frac{4}{16}}\ldots.)\times\left(1+\frac{z}{2}\right)^{\frac{1}{2}}\left(1+\frac{z}{4}\right)^{\frac{1}{4}}\left(1+\frac{z}{8}\right)^{\frac{1}{8}}\ldots;$$

and since the logarithm of the first factor of this expression is $\left(\frac{1}{2}+\frac{2}{4}+\frac{3}{8}+\frac{4}{16}+\text{\&c.}\right)\log 2$, or $=\frac{1}{2}\left\{1+2\left(\frac{1}{2}\right)+3\left(\frac{1}{2}\right)^2+4\left(\frac{1}{2}\right)^3+\text{\&c.}\right\}\log 2=\frac{1}{2}\left(1-\frac{1}{2}\right)^{-2}\log 2=2\log 2$, we have $\log a=2\log 2+\frac{1}{2}\log\left(1+\frac{z}{2}\right)+\frac{1}{4}\log\left(1+\frac{z}{4}\right)+\frac{1}{8}\log\left(1+\frac{z}{8}\right)+\text{\&c.}$

from which a value of z may be found by trial and error for any given value of a. Suppose $z=100$; on computing the first 10 terms of the series there results $a=107{\cdot}89$, whence (since $x=a-z$) $x=7{\cdot}89$; that is to say, if B possessed only 100 crowns before beginning the play, it would be morally disadvantageous for him to risk 8 crowns for the expectation, although its mathematical value be infinitely great. If we suppose $z=1000$, the sum of 11 terms gives $a=1011$, nearly; so that if B possessed a fortune of 1011 crowns, the value of the moral expectation would, to him, be about 11 crowns.

It is scarcely necessary to remark, that the results deduced from the principle of Bernoulli are of a character widely different from those which are calculated according to the mathematical expectation. The latter gives the precise value of a contingent benefit, without any assumption or hypothesis respecting the personal circumstances of the individual who may gain or lose it; whereas the considerations of relative advantage, of which it is the object of Bernoulli's theory to take account, are entirely arbitrary, and by their very nature incapable of being made the subject of accurate computation. It is evidently impossible to have regard to, or appreciate, all the circumstances which may render the same sum of money a more important benefit to one man than to another; and consequently every rule that can be given for the purpose must be liable to numerous exceptions. The principle, however, is thus far valuable, that it gives in the most common cases a plausible and judicious estimate of the value of things which are not susceptible of exact appreciation; and it has the advantage of being readily submitted to analysis. A different principle, proposed by the celebrated naturalist Buffon, consists in making the value itself of a casual benefit, instead of its infinitely small elements, inversely proportional to the fortune of the expectant; but as this hypothesis has seldom been adopted, it is unnecessary to discuss it in this place.

SECT. V.—OF THE PROBABILITY OF FUTURE EVENTS DEDUCED FROM EXPERIENCE.

42. In the preceding part of this article it has been assumed, in every case, that the number of chances favourable and unfavourable to the occurrence of a contingent event is known *a priori*, and consequently, that the probability of the event, or the ratio of the number of favourable cases to the whole number of cases possible, can be absolutely determined. But in numerous applications of the theory of probabilities, and these, generally speaking, by far the most important, the ratio of the chances in favour of an event to those which oppose it is altogether unknown; and we can form no idea of the probability of the event excepting from a comparison of the number of instances in which it has been observed to happen, with the whole number of instances in which it has been observed to happen and fail. In order to assign the probability of a contingent event in such cases, it is necessary to consider all the different causes or combinations of circumstances by which the event could possibly be produced, and to determine its probabilities successively on the hypotheses that each of these causes exists to the exclusion of all the others. The comparative facilities which these hypotheses give to the occurrence of the event which has actually arrived, will then enable us to determine the relative probabilities of the different hypotheses, and consequently their absolute probabilities, since their sum is necessarily equal to unity; and when the probabilities of the different hypotheses, and of the occurrence of the event on each hypothesis, have been determined, the probability of the event occurring in a future trial will be found by the methods already explained.

43. Taking a simple case, let us suppose an urn to contain 4 counters, which are either white or black; that the number of each colour is unknown, but in four successive drawings (the counter drawn being replaced in the urn after each trial) a white counter has been drawn three times, and a black one once; and let it be proposed to assign the probability of drawing a counter of either colour at the next trial.

In the present case three hypotheses may be formed relative to the number of white and black counters in the urn. 1st, The urn may contain 3 white counters and 1 black; 2d, It may contain 2 white and 2 black; 3d, It may contain 1 white and 3 black; for a counter of each colour having been drawn, the other two possible cases, namely, that they are all white or all black, are excluded by the observation. Now, let p_1, p_2, p_3, be the probabilities respectively of drawing a white counter on each hypothesis, and q_1, q_2, q_3, the probabilities of drawing a black. Supposing the first hypothesis to be true, or that the compound event which has been observed was produced by the cause indicated by that hypothesis, we have $p_1=\frac{3}{4}$, $q_1=\frac{1}{4}$; and the probability of the observed event, or that 3 white counters and 1 black would be drawn, (12) is $4p_1^3\,q_1=\frac{27}{64}$. The second hypothesis gives $p_2=\frac{1}{2}$, $q_2=\frac{1}{2}$, whence $4p_2^3\,q_2=\frac{16}{64}$. The third hypothesis gives $p_3=\frac{1}{4}$, $q_3=\frac{3}{4}$, whence $4p_3^3\,q_3=\frac{3}{64}$. The probabilities of the observed compound event, on each of the three hypotheses, are therefore, respectively, $\frac{27}{64}$, $\frac{16}{64}$, $\frac{3}{64}$; and the question now arises, how are the probabilities of the different hypotheses to be estimated? As we have no data, *a priori*, for determining this question, we must assume the probabilities of the different hypotheses to be respectively proportional to the probabilities they severally give of the observed compound event; in other words, we must assume the probability of any hypothesis to be greater or less according as it affords a greater or smaller number of combinations favourable to the event which has been observed to take place. Thus, if C and C_1 be two independent causes from which an observed event E may be supposed to arise, and C furnishes 20 different combinations out of a given number, favourable to the occurrence of E, while C_1 furnishes only 10 such combinations out of the same number, we naturally infer that the probability of the cause C having operated to produce E, is twice as great as the probability that the event was produced by the operation of the cause C_1. Applying this principle to the present example, the probabilities of the three hypotheses are respectively proportional to the three fractions $\frac{27}{64}$, $\frac{16}{64}$, $\frac{3}{64}$, or to the numbers 27, 16, 3; and as no other hypotheses are admissible, the sum of their probabilities must be unity; therefore, making ϖ_1 the probability of the first hypothesis, ϖ_2 that of the second, and ϖ_3 that of the third, we have

$$\varpi_1=\frac{27}{46},\quad \varpi_2=\frac{16}{46},\quad \varpi_3=\frac{3}{46}.$$

44. Having found the probabilities of the different hypotheses, that of drawing a white counter at the next trial

Probability is obtained without difficulty; for according to what was shewn in (9), the probability of this simple event must be equal to the sum of its probabilities relative to the different hypotheses, each multiplied into the probability of the hypothesis itself. Now it has been seen that, on the first hypothesis, the probability of drawing a white ball is $\frac{3}{4}$; on the second $\frac{2}{4}$, and on the third $\frac{1}{4}$; and that the probabilities of the hypotheses are respectively $\frac{27}{46}$, $\frac{16}{46}$, $\frac{3}{46}$; therefore the probability of a white counter being drawn at the next trial is

$$\frac{3}{4}\times\frac{27}{46}+\frac{2}{4}\times\frac{16}{46}+\frac{1}{4}\times\frac{3}{46}=\frac{116}{184}.$$

In like manner, the probability of a black counter being drawn at the next trial is

$$\frac{1}{4}\times\frac{27}{46}+\frac{2}{4}\times\frac{16}{46}+\frac{3}{4}\times\frac{3}{46}=\frac{68}{184};$$

and the sum of these two fractions is unity, as it ought to be, since the counter drawn must necessarily be white or black.

45. The reasoning which has been employed in this particular case is of general application. Let E be an observed event, simple or compound, of which the particular cause is unknown, but which may be ascribed to any one of the n causes, C_1, C_2, C_3,.....C_n, which, before the event has happened, are all equally probable, and such that the operation of any one of them excludes that of the others, so that the event E is produced by one of them alone, and not by the joint agency of several of them. Let the probabilities of the observed event E on the hypothesis that it has proceeded from each of those causes be respectively P_1, P_2, P_3,...P_n, so that if the cause, for instance, C_i were the true one, the probability of the event E, previous to the observation, would be P_i; and let the probabilities (as determined by the event) of the existence of the different causes be respectively ϖ_1, ϖ_2, ϖ_3,.....ϖ_n. From the principle laid down in the preceding paragraph, namely, that the probabilities of the different causes or hypotheses are proportional to the probabilities they respectively give of the observed event, we have

$$\varpi_1 : \varpi_2 : \varpi_3 ..... : \varpi_n :: P_1 : P_2 : P_3 ..... : P_n$$

whence, making $P_1+P_2,+P_3.....+P_n=\Sigma P_i$, and observing that $\varpi_1+\varpi_2+\varpi_3.....+\varpi_n=1$ (since it is assumed that there are no other causes than those specified from which the event could arise), we have

$$\varpi_1=\frac{P_1}{\Sigma P_i},\ \varpi_2=\frac{P_2}{\Sigma P_i},\ \varpi_3=\frac{P_3}{\Sigma P_i},\ .....\varpi_n=\frac{P_n}{\Sigma P_i},$$

whence it appears that the probability of each hypothesis respecting the cause of the observed event is found by dividing the probability of the event on the supposition that that particular cause alone existed, by the sum of its probabilities in respect of all the causes. Let us now assume the probabilities of a future event E′ (which may be the same with E or different, but depending on the same causes) in respect of the several hypotheses, to be, p_1, p_2, p_3,.....p_n; so that if the particular cause C_i be the true one, the probability of E′ is p_i; and let Π be the probability of E′ in respect of all the causes, then by (9), Π will be equal to the sum of the probabilities p_1, p_2, p_3.....p_n relative to the different hypotheses, each multiplied by the probability of the hypothesis; that is to say we shall have

$$\Pi=p_1\varpi_1+p_2\varpi_2+p_3\varpi_3.....+p_n\varpi_n;$$

or $\Pi=\Sigma p_i\varpi_i$, the symbol Σ indicating the sum of all the different values of p and ϖ in respect of the different causes C_1, C_2, C_3,.....C_n.

46. It may be worth while to remark that the word cause is not here used in its ordinary acceptation to denote the combination of circumstances, physical or moral, of which the event is a *necessary* consequence. In the sense we have used the term, the cause C is that which gives rise to the determinate probability P, that the event E will happen; but so long as this probability falls short of certainty, its existence also implies that of another probability, 1—P, that the contrary event F will happen. If we make P=1, the existence of the cause C would necessarily involve the occurrence of E; and it is in this particular sense that the word cause is ordinarily used. In the theory of probabilities the causes of events are considered only in reference to the number of chances they afford for the occurrence of those events which they may possibly, but do not necessarily, produce.

47. The following example may serve to illustrate the method of applying the preceding formulæ. An urn contains n balls, which are known to be either white or black. A ball is drawn at random and found to be white; required the probability of drawing a white ball at the next trial?

In this case, the number of hypotheses that may be made respecting the contents of the urn, is n; for we may suppose that it contained one, or two, or any number of white balls from 1 to n, and each of these cases may be considered as a distinct cause of the observed event E. Let these causes or hypotheses be C_1, C_2, C_3,.....C_n, and let us suppose the true cause was C_i, or that the urn contained i white balls. On this hypothesis the probability of the observed event E is $\frac{i}{n}$, whence $P_i=\frac{i}{n}$; and therefore, making i successively equal to 1, 2, 3,....n, we have $\Sigma P_i=\frac{1}{n}(1+2+3..+n)$. But the sum of this arithmetical series is $\frac{n(n+1)}{2}$, therefore $\Sigma P_i=\frac{1}{2}(n+1)$, and consequently,

$$\varpi_i=\frac{P_i}{\Sigma P_i}=\frac{2i}{n(n+1)},$$

which is the probability of the assumption that the event proceeded from the cause C_i, or that the urn contained i white balls. If we suppose $i=n$ we have $\varpi_n=\frac{2}{n+1}$ for the probability that all the balls are white; and if we also suppose $n=3$, this becomes $\frac{1}{2}$; whence if an urn contain 3 balls which must be either black or white, and a white ball be drawn at the first trial, it is an even wager, after the trial, that all the balls are white.

48. Having found, from the observed event E, the probabilities of the different hypotheses, we have now to determine the probability Π of the event E′ (the drawing of a white ball) at the next trial. Here two cases present themselves; according as the ball is replaced in the urn, or is not; or in general, according as the law of the chances remains constant during the series of trials or varies.

1st, Let us suppose that the ball has been replaced in the urn. In this case the probability of the event E′, on the hypothesis that the urn contains i white balls, is $\frac{i}{n}$; that is to say $p_i=\frac{i}{n}$. But the probability ϖ_i of this hypothesis, as found above, is $\frac{2i}{n(n+1)}$; therefore $p_i\varpi_i=\frac{2i^2}{n^2(n+1)}$; whence the general formula (45) $\Pi=\Sigma p_i\varpi_i$ becomes $\Pi=\Sigma\frac{2i^2}{n^2(n+1)}=\frac{2}{n^2(n+1)}\Sigma i^2$. Now $\Sigma i^2=\Sigma i(i+1)-\Sigma i$. But by the property of the figurate numbers referred to in (23), the sum of the series of numbers obtained by giving i every value from $i=1$ to $i=n$ in the formula $\frac{n(n+1)}{1.2}$ is expressed by $\frac{n(n+1)(n+2)}{1.2.3}$; therefore $\Sigma i(i+1)=\frac{n(n+1)(n+2)}{3}$.

Probability

We have also as above

$$\Sigma i = 1+2+3.....+n = \frac{n(n+1)}{2};$$

consequently,

$$\Sigma i^2 = \frac{n(n+1)(n+2)}{3} - \frac{n(n+1)}{2} = \frac{n(n+1)(2n+1)}{2 \cdot 3}$$

and therefore

$$\Pi = \frac{2}{n^2(n+1)} \times \frac{n(n+1)(2n+1)}{2 \cdot 3} = \frac{2n+1}{3n}.$$

2d, Suppose the ball which has been extracted is not replaced in the urn. In this case, on the hypothesis that the urn at first contained i white balls, the probability of drawing a white ball at the next trial is $\frac{i-1}{n-1}$; that is, $p_i = \frac{i-1}{n-1}$; and the probability of the hypothesis is the same as in the former case, or $\varpi_i = \frac{2i}{n(n+1)}$; therefore $p_i \varpi_i = \frac{2i(i-1)}{(n-1)n(n+1)}$; and consequently $\Pi = \Sigma p_i \varpi_i = \frac{2}{(n-1)n(n+1)} \Sigma i(i-1)$. Now the value of $\Sigma i(i-1)$ will evidently be found by writing $n-1$ for n in the above expression for $\Sigma i(i+1)$; whence $\Sigma i(i-1) = \frac{(n-1)n(n+1)}{3}$, and, therefore, in this case

$$\Pi = \frac{2}{(n-1)n(n+1)} \times \frac{(n-1)n(n+1)}{3} = \frac{2}{3}.$$

When n is a very large number, the ratio of $2n+1$ to $3n$, the value of Π in the former case, does not sensibly differ from $\frac{2}{3}$, and therefore in both cases $\Pi = \frac{2}{3}$. Hence it follows, that if an event, depending on unknown causes, can happen only in one of two ways, and it has been observed to happen once, the odds are two to one in favour of its happening in the same way at the next occurrence.

49. The expression for ϖ in (45) was determined on the supposition that previously to the experiments being made, we are entirely ignorant of the relative numbers of the two sorts of balls in the urn, and have no reason to suppose one hypothesis more probable than another. If, however, we happen to know, previously to the experiment, that the different causes C_1, C_2, C_3, &c. have not all the same number of chances in their favour, or that the probabilities of the different hypotheses have relative values, it becomes necessary to introduce those relative values, in consequence of which ϖ_1, ϖ_2, &c., will receive a modification. Let us conceive a number of urns, each containing balls of two colours, black and white, to be distributed in n groups, A_1, A_2, A_3.....A_n, in such a manner that the ratio of the number of white balls to the number of black balls is the same in respect of each urn belonging to the same group, and consequently that the probability of drawing a ball of either colour is the same from whichever urn in the group it may happen to be drawn, but different in respect of the different groups; and let the probabilities of drawing a white ball from each of the different groups be respectively P_1, P_2, P_3,.....P_n. Now, let us suppose there are a_1 urns in the group A_1, a_2 in the group A_2, and so on, and let $s =$ the whole number of urns, so that $s = a_1 + a_2 + a_3 + \ldots\ldots + a_n$; then, if we make $\frac{a_1}{s} = \lambda_1$, $\frac{a_2}{s} = \lambda_2$, and so on, λ_1 will be the *a priori* probability that a ball drawn from any urn at random, will be drawn from the group A_1; λ_2 the probability it will be drawn from the group A_2; and, in general, λ_i the probability it will be drawn from the group A_i. This being premised, suppose a trial to be made, and that the event E is a white ball; the probability ϖ_i of the hypothesis that the ball was drawn from the group A_i is found as follows. The *a priori* probability of the ball being drawn from the group A_i is λ_i; and if the ball is actually drawn from that group, the probability of its being white is P_i; therefore the probability of both events is $\lambda_i P_i$; and consequently (45), $\varpi_i = \frac{\lambda_i P_i}{\Sigma \lambda_i P_i}$, the symbol of summation Σ extending to all the values of i from $i=1$ to $i=n$.

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50. In the applications of the theory to physical or moral events, the different groups of urns here imagined may be regarded as so many independent causes C_1, C_2, C_3, &c. by any one of which the event E might have been produced; ϖ_i is the probability that the event was produced by the particular cause C_i; P_i is the probability that the cause C_i if it had alone existed, would have produced the observed event E; and λ_i is the probability, previously to the experiment, that C_i would be the efficient cause. The formula $\varpi_i = \frac{\lambda_i P_i}{\Sigma \lambda_i P_i}$, therefore, shews that the probability of any one of the possible causes (C_i) of an observed event is equal to the product of the probability (P_i) of the event taking place if that cause acted alone multiplied into the probability λ_i that the cause C_i is the true one, and divided by the sum ($\Sigma \lambda_i P_i$) of all the similar products formed relatively to each of the causes from which the event can be supposed to arise.

51. The formulæ now obtained can only be used when the number of hypotheses is finite; but in the applications of the theory it most frequently happens that an infinite number of hypotheses may be made respecting the causes of an observed event, as would be the case in the above example if the number of balls in the urn had been unknown. In such cases, in order to find the values of ϖ and Π, it becomes necessary to transform the sums Σ into definite integrals, which is accomplished by means of the theorem $\Sigma X = \int_0^1 X\, dx$, where X is a function of x. Suppose a ball to have been drawn a great number of times in succession from an urn (the number in which is unknown) and replaced in the urn after each drawing, and that the result has been a white ball m times and a black ball n times, the probable constitution of the urn, and thence the probability of drawing a white ball at a future trial will be found as follows. Assume the hypothesis that the ratio of the number of white balls to the whole number in the urn is $x : 1$, and let ϖ be the probability of the hypothesis. On this hypothesis the probability of drawing a white ball in any trial is x, and that of drawing a black ball $1-x$, and consequently, the probability of drawing m white and n black in $m+n$ trials is $Ux^m(1-x)^n$ by (12). We have therefore for the probability of the observed compound event $P = Ux^m(1-x)^n$; whence in consequence of the above formula for transforming a sum into a definite integral $\Sigma P = U \int_0^1 x^m(1-x)^n\, dx$ (U being independent of x) and therefore

$$\varpi = \frac{P}{\Sigma P} = \frac{x^m(1-x)^n}{\int_0^1 x^m (1-x)^n\, dx}.$$

The value of the integral in the denominator of this fraction is obtained by the usual method of integrating by parts. Since

$$d\,\frac{x^{m+1}(1-x)^n}{m+1} = x^m(1-x)^n dx - \frac{n}{m+1} x^{m+1}(1-x)^{n-1} dx,$$

therefore

$$\int x^m(1-x)^n dx = \frac{x^{m+1}(1-x)^n}{m+1} + \frac{n}{m+1} \int x^{m+1}(1-x)^{n-1} dx,$$

In like manner we get $\int x^{m+1}(1-x)^{n-1} dx$

$$= \frac{x^{m+2}(1-x)^{n-1}}{m+2} + \frac{n-1}{m+2} \int x^{m+2}(1-x)^{n-2} dx.$$

Continuing this operation n times, or till the exponent of $(1-x)$ becomes $n-n=0$, the last integral will be

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$$\int x^{m+n}dx = \frac{x^{m+n+1}}{m+n+1};$$

therefore, collecting the several terms into one sum, we have

$$\int x^m(1-x)^n dx = \frac{x^{m+1}(1-x)^n}{m+1} + \frac{nx^{m+2}(1-x)^{n-1}}{(m+1)(m+2)} \cdots\cdots$$
$$\cdots\cdots + \frac{n(n-1)(n-2)\cdots\cdots 2\,.\,1\,.\,x^{m+n+1}}{(m+1)(m+2)\cdots\cdots\ m+n+1}.$$

When $x=0$, all the terms of this series vanish, and when $x=1$ they all vanish excepting the last; therefore between the limits $x=0$ and $x=1$, the value of the integral is the last term of the series when x in that term $=1$; that is to say,

$$\int_0^1 x^m(1-x)^n dx = \frac{n(n-1)(n-2)\cdots\cdots\ 2\,.\,1}{(m+1)(m+2)\cdots\cdots m+n+1}.$$

For the sake of brevity, let the symbol $[x]$ be adopted to represent the continued product $1\,.\,2\,.\,3\ldots x$ of the natural numbers from 1 to x,[1] whence by analogy $[x+y]$ will represent the continued product of the same series from 1 to the number denoted by $x+y$. Multiplying, then, the numerator and denominator of the above expression by $1\,.\,2\,.\,3\ldots$ $\ldots m=[m]$, we get

$$\int_0^1 x^m(1-x)^n dx = \frac{[m][n]}{[m+n+1]};$$

whence the probability of the hypothesis, in consequence of the equation above found, becomes

$$\varpi = \frac{[m+n+1]}{[m][n]}\, x^m(1-x)^n.$$

From this value of ϖ we are enabled to deduce that of Π, the probability of drawing a white ball at the next trial. By (45) $\Pi=\Sigma\varpi p$. Now, since by hypothesis the number of white balls in the urn is to the whole number of both colours in the ratio of x to 1, the probability of drawing a white ball is x; consequently $p=x$, and therefore $\Pi=\Sigma\varpi x=$ $\int_0^1 \varpi x dx = \frac{[m+n+1]}{[m][n]} \int_0^1 x^{m+1}(1-x)^n dx$. But the value of $\int_0^1 x^{m+1}(1-x)^n dx$ will evidently be obtained by substituting $m+1$ for m in the expression found for $\int_0^1 x^m (1-x)^n dx$. This substitution gives

$$\int_0^1 x^{m+1}(1-x)^n dx = \frac{[m+1][n]}{[m+n+2]},$$

whence, observing that $[m+1] \div [m] = m+1$, and $[m+n+2] \div [m+n+1] = m+n+2$, we have

$$\Pi = \frac{m+1}{m+n+2}.$$

The probability of the contrary event, or of drawing a black ball, is $1-\Pi = \frac{n+1}{m+n+2}$. As the numbers m and n become larger, these two fractions approach nearer and nearer to their limits $\frac{m}{m+n}$ and $\frac{n}{m+n}$, which are the *apriori* probabilities p and q of the respective events when the ratio of the number of white balls in the urn is to that of the black balls as m to n.

52. The probability of drawing m' white balls and n' black balls in $m'+n'$ future trials is found in a similar manner, and the problem may be thus stated. E and F are two contrary events, depending on constant but unknown causes; and it has been observed, that in $m+n=h$ successive instances the event E has occurred m times and F n times, required the probability that in $m'+n'=h'$ future instances, E will occur m' times and F n' times.

Assume, as in the last case, the facility of the occurrence of E to that of F to be in the ratio of x to $1-x$; we have then, as before, for the probability of the hypothesis, $\varpi = \frac{[h+1]}{[m][n]} x^m(1-x)^n$. Now on this hypothesis the probability of E in the next instance is x, and that of F is $1-x$, whence the probability of m' times E and n' times F in the next h' trials being denoted by p, we have (12) $p=\mathrm{U}'\, x^{m'}(1-x)^{n'}$, making $\mathrm{U}' = \frac{1\,.\,2\,.\,3\ldots h'}{1\,.\,2\,.\,3\ldots m' \times 1\,.\,2\,.\,3\ldots n'} = \frac{[h']}{[m'][n']}$. We have therefore $\varpi p = \mathrm{U}' \frac{[h+1]}{[m][n]} x^{m+m'}(1-x)^{n+n'}$ for the probability of the compound event on this hypothesis. To find its probability Π on the infinite number of hypotheses formed by supposing x to increase by infinitely small increments from $x=0$ to $x=1$, we have $\Pi=\Sigma\varpi p = \int_0^1 \varpi p dx$. On substituting for ϖp the value just found, we get $\Pi = \mathrm{U}' \frac{[h+1]}{[m][n]} \int_0^1 x^{m+m'}(1-x)^{n+n'} dx$, and it is manifest that the value of this integral will be obtained by substituting $m+m'$ for m, and $n+n'$ for n in the value of $\int_0^1 x^m(1-x)^n dx$ found above. This substitution gives

$$\int_0^1 x^{m+m'}(1-x)^{n+n'} dx = \frac{[m-m][n+n']}{[h+h'+1]},$$

whence we conclude

$$\Pi = \mathrm{U}' \frac{[m+m'][n+n'][h+1]}{[m][n][h+h'+1]}.$$

The most probable hypothesis will be found by making the value of ϖ a maximum, or its differential coefficient equal to zero. Differentiating the equation $\varpi = \frac{[h+1]}{[m][n]} x^m(1-x)^n$, and making $\frac{d\varpi}{dx} = 0$, we get $m(1-x)=nx$, whence $x = \frac{m}{m+n}$. The most probable supposition, therefore, respecting the contents of the urn is, that the two sorts of balls are in the same proportions as have been shewn by the previous drawings. We shall have further occasion for these formulæ when we come to consider the cases in which m and n are large numbers.

SECT. VI.—OF BENEFITS DEPENDING ON THE PROBABLE DURATION OF HUMAN LIFE.

53. In applying the principles of the theory of probability to the determination of the values of benefits depending on life, the fundamental element which it is necessary to determine from observation is the probability that an individual at every given age within the observed limits of the duration of life, will live over a given portion of time, for instance one year; for when this has been determined for each year of age, the probability that an individual, or any number of individuals, will live over any assigned number of years, is easily deduced. Thus, if the probabilities that an individual A, whose age is y, will live over 1, 2, $3\ldots x$ years, be denoted respectively by $p_1, p_2, p_3 \ldots p_x$; and if $q_1, q_2, q_3 \ldots q_x$ denote the same probabilities in respect of an individual whose age is $y+1$ years; $r_1, r_2, r_3 \ldots r_x$, the same in respect of an individual whose age is $y+2$ years, and so on; then, since the probability p_2 which A has of living over 2 years is obviously compounded of the probability p_1 of his living over 1 year, and of the probability q_1 that, having attained the age $y+1$, he will live another year, we

[1] This convenient notation has been adopted by Mr. De Morgan.

Probability. have, by (7), $p_2=p_1q_1$. Again, the probability p_3 that A will live over three years, being compounded of the probability p_2 that he will live over two years, and of the probability r_1 that, having attained the age $y+2$ years, he will survive another year, we have $p_3=p_2r_1=p_1q_1r_1$. In like manner $p_4=p_1q_1r_1s_1$, and so on; so that the probabilities p_2, p_3, $p_4 \ldots p_x$ are successively derived from p_1, q_1, r_1, s_1, &c. which are supposed to be the data of observation.

If a large number n of individuals, all born in the same year, were selected, and if it were observed that the number of them remaining alive at the end of the first year is n_1, at the end of the second year n_2, at the end of the third n_3, and so on, then the probabilities p_1, p_2, p_3, &c. would be given directly by the observation, being respectively equal to the quotients $\frac{n_1}{n}$, $\frac{n_2}{n}$, $\frac{n_3}{n}$, &c. But the most accurate observations of mortality are furnished by the experience of the annuity and assurance offices, where they are not made on an isolated number, diminishing, and consequently giving a less valuable result every year, but on a comparison of the numbers which, in a series of years, enter upon and survive each year of age. This observation gives p_1, q_1, r_1, s_1, &c, whence p_2, p_3, p_4, &c. are found, as above, for every year of life.[1]

54. The values of annuities on lives, and of reversionary sums to be paid on the failure of lives, are found by combining the probabilities p_1, p_2, p_3, &c. with the rate of interest of money. Let $r=$ the rate of interest, that is to say, the interest of L.1 for a year, and $v=$ the present value of L.1 to be received at the end of a year, we shall then have $v=1\div(1+r)$. Now an annuity, payable yearly, is always understood in this sense, that the first payment becomes due at the end of a year after the annuity is created. Suppose then the annuity to be L.1, the present value of the first payment, if it were to be received certainly, is v; but the receipt of this sum is contingent on the annuitant being alive at the end of the year, the probability of which we suppose to be p_1; therefore (7) the present value of L.1 subject to the contingency, is vp_1. In like manner, the present value of L.1 to be received certainly at the end of x years is v^x; but the annuity will only be received at the end of the xth year if the annuitant be then living, the probability of which is p_x; therefore the present value of that particular payment is v^xp_x. Hence if A denote the present value of the annuity, or the sum in hand which is equivalent to all the future payments, we shall have $A=\Sigma v^xp_x$; the sum Σ including all values of x from $x=1$ to $x=$ the number for which $p=0$. If the annuity be a pounds, its value is obviously $=a\Sigma v^xp_x=aA$.

55. The series denoted by Σv^xp_x may be divided into two parts, $\Sigma v^np_n+\Sigma v^zp_z$, where n is to be taken from 1 to n, and z from $n+1$ to the number for which p vanishes. The first gives the value of the *temporary* annuity on the given life for n years, and the second the value of the *deferred* annuity, that is to say, of the annuity to commence n years hence if the individual shall be then living, and to continue during the remainder of his life. Let A be the value of the annuity on the life of a person now aged y years for the whole of life, $A^{(tn)}$ the value of a temporary annuity on the same life for n years, and $A^{(dn)}$ the value of an annuity deferred n years on the same life, we have then $A=A^{(tn)}+A^{(dn)}$.

To find $A^{(dn)}$, let A_n be the value of an annuity on a life aged $y+n$ years. If the person now aged y years lives over n years, the value of an annuity on the remainder of his life will *then* be A_n. The present value of this sum, if it were to be received certainly, is v^nA_n, and the probability of receiving it is p_n; therefore its value is $v^np_nA_n$. Hence

$$A^{(dn)}=v^np_nA_n, \text{ and } A^{(tn)}=A-v^np_nA_n;$$

so that the values of temporary and deferred annuities are readily computed from tables of A and p for all the different ages. Probability

56. The equation $A=A^{(tn)}+A^{(dn)}$ gives a formula by which the values of A are readily deduced from one another. Let $n=1$; we have then $A=A^{(t1)}+vp_1A_1$. But $A^{(t1)}$, the value of an annuity for one year, is merely the value of the first payment to be received in the event of the given life surviving one year. Its value is therefore vp_1; and we have consequently $A=vp_1+vp_1A_1$, or $A=vp_1(1+A_1)$. This formula, which gives the value of an annuity at any age in terms of the next higher age, and greatly facilitates the computation of the annuity tables, is due to Euler.

57. The value of an annuity on the joint lives of any number of individuals, that is, to continue only while they are *all* living, is calculated precisely in the same manner as the annuity on a single life. Let there be any number of individuals, A, B, C, D, &c. and let the probabilities of each living over one year be respectively p_1, q_1, r_1, s_1, &c. and let P_1 be the probability that they will *all* live over one year; then

$$P_1=p_1\times q_1\times r_1\times s_1, \text{ &c.}$$
$$P_2=p_2\times q_2\times r_2\times s_2, \text{ &c.}$$
$$\ldots\ldots\ldots\ldots\ldots\ldots$$
$$P_x=p_x\times q_x\times r_x\times s_x, \text{ &c.}$$

and the value of an annuity of L.1 on the joint lives is Σv^xP_x, from $x=1$ to $x=$ the number which renders any one of the probabilities p, q, r, s, &c. nothing.

58. The value of an annuity on the survivor of any number of given lives, that is, to continue so long as any one of them exists, is thus found. The probability that A will be alive at the end of the xth year being p_x, the probability that he will not be alive at the end of that time is $1-p_x$. The probability that *all* the lives will be extinct at the end of the xth year is therefore

$$(1-p_x)(1-q_x)(1-r_x)(1-s_x), \text{ &c.}$$

and the probability that they will not all be extinct, or that at least one of them will be in being, is

$$1-(1-p_x)(1-q_x)(1-r_x)(1-s_x), \text{ &c.}$$

which becomes by multiplication

$$p_x+q_x+r_x+s_x+\text{&c.}$$
$$-p_xq_x-p_xr_x\ldots\ldots-q_xr_x-q_xs_x\ldots\ldots-r_xs_x-\text{&c.}$$
$$+p_xq_xr_x+p_xq_xs_x\ldots\ldots+q_xr_xs_x+\text{&c.}$$
$$-p_xq_xr_xs_x-\text{&c.}$$
$$+\text{&c.}$$

Multiplying each of the terms by v^x, and taking the sums of the respective products from $x=1$, and observing that $\Sigma v^xp_xq_x$ is the value of the annuity on the joint lives of A and B, $\Sigma v^xp_xq_xr_x$ that on the joint lives of A, B, and C, and so on, we have this rule:—

The value of an annuity on the survivor of any number of lives is equal to the sum of the annuities on each of the lives, minus the sum of the annuities on each pair of joint lives, plus the sum of the annuities on the joint lives taken by threes, and so on. When there are only two lives, the value of the annuity on the life of the survivor becomes

$$\Sigma v^xp_x+\Sigma v^xq_x-\Sigma v^xp_xq_x.$$

59. Let V denote the value of an assurance on the life of A, or the present worth of L.1 to be received at the end of the year in which A shall die. In respect of any year, the xth, after the present, the probability of A dying in the course of that year is $p_{x-1}-p_x$. For let u be the probability that a life $x-1$ years older than A will live over one year, then $1-u$ is the probability of a life of that age not living over one year; therefore p_{x-1} being the probability of A living over $x-1$ years, $p_{x-1}(1-u)$ is the chance of his living over $x-1$ years, and dying in the following year (7). But $p_{x-1}(1-u)=p_{x-1}-p_{x-1}u$; and by (53), $p_{x-1}u=p_x$; therefore $p_{x-1}-p_x$ is the chance that A will survive $x-1$

[1] For further details on this subject, see MORTALITY, vol. xv. p. 550.

Probability. years and not survive x years. Now v^x is the value of L.1 to be received certainly at the end of the xth year; therefore in respect of the xth year the value of the expectation is $v_x(p_{x-1}-p_x)$; whence we have for the value of the assurance

$$V=\Sigma v^x(p_{x-1}-p_x),$$

from $x=1$ to $x=$ the number which makes $p=0$. Now, if we observe that $p_0=1$, and $\Sigma v^x p_{x-1}=v\Sigma v^{x-1}p_{x-1}$, it will be obvious that $\Sigma v^x p_{x-1}=v(1+\Sigma v^x p_x)$; whence, denoting $\Sigma v^x p_x$ by A, (A being as in (54) the value of the annuity on the given life), we have

$$V=v(1+A)-A\text{; or } V=v-(1-v)A.$$

60. The values of assurances on joint lives, (that is, to be paid at the end of the year in which any one of the lives shall fail), or on the survivor of any number of joint lives, are calculated from the corresponding annuities by means of the same formula. Thus, let A′ be the value of an annuity of L.1 on any number of joint lives, and V′ the value of an assurance of L.1 on the same joint lives, then $V'=v-(1-v)A'$. If A″ be the annuity, and V″ the assurance on the life of the survivor of any number of given lives, we have still $V''=v-(1-v)A''$.

61. Assurances on lives are usually paid not in single payments, but by equal yearly payments, the first being made at the time the contract is entered into, and the succeeding ones at the end of each future year during the life of the assured. The present value of the sum which the assured contracts to pay is therefore equal to the first payment added to the value of an annuity of the same amount on his life; and if the assurance is made on terms of mathematical equality, this sum must be precisely equal to the value of the assurance in a single payment. Therefore, if y denote the amount of the yearly payment, we have the equation $y(1+A)=V$; whence $y=V\div(1+A)$.

62. The value of a temporary assurance for n years, that is, of an assurance to be paid only in the event of the individual dying before the end of n years is thus found. Let V be the present value of L.1, to be paid on the death of a person now aged y years, and V_n the present value of L.1, to be paid on the death of a person now aged $y+n$ years. At the end of n years from the present time, the value of L.1 assured on the life of a person now aged y years will be V_n, if he be then living. But the present value of L.1 to be received certainly at the end of n years is v^n; and the probability that the life will continue n years is p_n; therefore the present value of V_n, subject to the contingency of the life continuing n years, is $v^n p_n V_n$. If, therefore, we subtract this from V, we shall have the value of the temporary assurance in a single payment, namely $V-v^n p_n V_n$.

The equivalent annual premium is found by observing, that as the first payment is made immediately, and n payments are to be made in all, the value of all the premiums after the first is that of a temporary annuity of the same amount for $n-1$ years. Denoting therefore the annual premium by u, and the value of a temporary annuity for $n-1$ years by $A^{(tn')}$, the value of all the premiums is $u+uA^{(tn')}=u(1+)A^{(tn')}$; and we have consequently $u(1+A^{(tn')})=V-v^n p_n V_n$, whence

$$u=\frac{V-v^n p_n V_n}{1+A^{(tn')}}.$$

63. The following question is of frequent occurrence. Required the present value of a sum of money to be received at the end of the year in which A dies, provided he die while B is living.

Let the sum be L.1, W= its present value, $p_x=$ the probability of A living over x years, and $q_x=$ the probability of B living over x years. The chance of receiving the sum at the end of any given year, the xth, depends on two contingencies; 1. A may die in the course of that year, and B live over it; 2. A and B may both die in that year, A dying first. The probability of A dying in the xth year has been shewn (59) to be $p_{x-1}-p_x$; whence (7) the probability of the first contingency is $(p_{x-1}-p_x)q_x$. The probability that A and B will both die in the xth year is $(p_{x-1}-p_x)(q_{x-1}-q_x)$; and for so short a period as one year, it may be considered an even chance whether A or B will die first, whatever be the difference of their ages; therefore the probability in respect of the second contingency is $\frac{1}{2}(p_{x-1}-p_x)(q_{x-1}-q_x)$. Hence the whole probability of the sum being received at the end of the xth year, is $(p_{x-1}-p_x)q_x+\frac{1}{2}(p_{x-1}-p_x)(q_{x-1}-q_x)=\frac{1}{2}(p_{x-1}-p_x)(q_{x+1}+q_x)$, which being developed, and multiplied by v^x, becomes

$$\tfrac{1}{2}v^x(p_{x-1}q_{x-1}+p_{x-1}q_x-p_xq_{x-1}-p_xq_x),$$

and the sum of all the values of this expression from $x=1$, gives the value of W.

It has been already shewn (59) that $\Sigma v^x(p_{x-1}-p_x)=v-(1-v)A$, where A= the annuity on the life of A. In like manner, if we denote by $\overline{AB}$ the value of an annuity on the joint lives of A and B, we shall have $\Sigma v^x(p_{x-1}q_{x-1}-p^xq^x)=v-(1-v)\overline{AB}$, which is the value of an assurance to be paid on the death of the first dying. Assume p' such that $p'_x=p'_1p_{x-1}$, then p'_x is evidently the probability that an individual A′ one year *younger* than A, will live over x year (53), and $\Sigma v^x p_{x-1}q_x=\frac{1}{p'_1}\Sigma v^x p'_x q_x=\frac{1}{p'_1}\overline{A'B}$; denoting by $\overline{A'B}$ the value of an annuity on the joint lives of A′ and B. Again, let $q'_x=q'_1q_{x-1}$, then q'_x is the probability that B′, who is one year *younger* than B, will live over x years, and $\Sigma v^x p^x q_{x-1}=\frac{1}{q'_1}\Sigma v^x p_x q'_x=\overline{AB'}$; denoting by $\overline{AB'}$ the value of an annuity on the joint lives of A and B′. Collecting the different terms, we have therefore

$$W=\tfrac{1}{2}\left\{v-(1-v)\overline{AB}+\frac{1}{p'_1}\overline{A'B}-\frac{1}{q'_1}\overline{AB'}\right\},$$ whence W is easily computed from tables of annuities on joint lives.

If A and B are both of the same age, the two last terms destroy each other, and W is equal to $\frac{1}{2}$ the value of L.1, to be paid on the failure of the joint lives, as it evidently ought to be, since there is in this case the same chance of A dying before B as of B dying before A.

The formula gives the value of L.1 in a single payment; the equivalent yearly payment is W divided by $1+\overline{AB}$, for the contract ceases on the failure of the joint lives by the death of either.

It would be easy to extend the formula to the case of an assurance to be paid on the contingency of the failure of any number of lives during the continuance of any number of other lives, or of an assurance to continue only during a stated time; but as it is not our purpose to give solutions of the various problems of this kind which may occur in practice, but merely to shew the manner in which the general principles of the theory are applied to them, we shall not pursue the subject farther, but refer the reader to the article ANNUITIES, and to the standard works of Baily[1] and Milne,[2] in which it is treated in detail.

SECT. VII. OF THE APPLICATION OF THE THEORY OF PROBABILITY TO TESTIMONY, AND TO THE DECISIONS OF JURIES AND TRIBUNALS.

64. The case of a witness making an assertion may be represented by an urn containing balls of two colours, the

[1] *The Doctrine of Life Annuities and Assurances analytically investigated and practically explained, &c.* By Francis Baily. London, 1813. This work is now out of print, but a French translation of it has recently been published at Paris.

[2] *A Treatise on the Valuation of Annuities and Assurances on Lives and Survivorships, &c.* By Joshua Milne. London, 1815.

Probability. ratio of the number of one colour to that of the other being unknown, but presumed from the result of a number of experiments, which consist in drawing a ball at random, and replacing it in the urn after each trial. A true assertion being represented by a ball of one colour, and a false one by a ball of the other, it follows from the theorem in (51), that if a witness has made $m+n$ assertions, of which m are true and n false, the probability of a future assertion being true is $\frac{m+1}{m+n+2}$, and that of its being false $\frac{n+1}{m+n+2}$. Let the first of these fractions be represented by v, and the second by w, then v is the measure of the veracity of the individual, or the probability of his speaking the truth, and w the opposite probability, since $v+w=1$. In general, the existing data are insufficient to enable us to determine the numerical values of v and w in this manner; and therefore in applying the formulæ to particular cases, we must assign arbitrary values to these quantities, founded on previous knowledge of the moral character of the individual, or on some notions, more or less sanctioned by experience, of the relative number of true and false statements made by men in general, placed in similar circumstances.

65. Having assumed v and w, let us suppose a witness to testify that an event has taken place, the *a priori* probability of which is p, and let it be proposed to determine the probability of the event after the testimony. In this case the event observed (E) is the assertion of the witness, and two hypotheses only can be made respecting its cause; 1st, that the event testified really took place; and 2d, that it did not. On the first hypothesis the witness has spoken the truth, the probability of which is v; and an event has occurred of which the probability is p; therefore (7) the probability (P_1) of the coincidence is vp. On the second hypothesis, the witness has testified falsely, the probability of which is w; and the event attested did not happen, the probability of which is q; therefore the probability (P_2) of the coincidence is wq. Hence, by the formula (47) $\varpi_1 = P_t \div \Sigma P_t$) the probability ($\varpi_1$, of the first hypothesis becomes $\frac{vp}{vp+wq}$, and the probability (ϖ_2) of the second $\frac{wq}{vp+wq}$. The sum of these two probabilities is unit, a condition which ought evidently to be fulfilled, since no other hypothesis can be made, and consequently one or other of the two must be true. It is to be observed, that these values of ϖ_1 and ϖ_2 are the respective probabilities, after the testimony has been given, that the event attested took place, and that it did not.

Since $\varpi_1 = \frac{vp}{vp+wq}$, we have $\varpi_1 - p = \frac{p(v-vp-wq)}{vp+wq} = \frac{p\{v(1-p)-wq\}}{vp-wq} = \frac{p(vq-wq)}{vp-wq}$; but $v-w=v-1+v=2v-1$, therefore $\varpi_1 - p = \frac{p(2v-1)q}{vp+wq}$. This fraction being positive or negative, according as $2v-1$ is greater or less than unity, or as v is greater or less than $\frac{1}{2}$, it follows that if $v > \frac{1}{2}$, then $\varpi_1 > p$; that is to say, the probability of the event after the testimony is greater than its *a priori* probability when the veracity of the witness is greater than $\frac{1}{2}$. On the contrary, if the veracity of the witness is less than $\frac{1}{2}$, the effect of the testimony is to render the probability of the event less than its *a priori* probability.

66. If the event asserted by the witness be of such a nature that its occurrence is *a priori* extremely improbable, so that p is a very small fraction, and q consequently approaches nearly to unity, although at the same time the veracity of the witness be great, and measured by a fraction approaching to unity, the value of ϖ_1 becomes nearly equal to $p \div w$, (for on this supposition $p+wq : v$ is nearly equal to w). But it is obvious, that however great the improbability of a witness giving false testimony may be supposed, the improbability of a physical event may be any number of times greater; in other words, however small a value may be given to w, the value of p may still be any number of times smaller; so that notwithstanding the veracity of the witness, the probability of the event after the testimony, namely $\varpi_1 = p \div w$ may be less than any assignable quantity. On this principle mankind do not easily give credence to a witness asserting a very extraordinary or improbable event. The odds against the occurrence of the event may be so great, that the testimony of no single witness, however respectable his character, would suffice to induce belief.

Probability.

67. In the case of the character of a witness being altogether unknown, we may suppose v to have all possible values within certain limits, and to find the value of ϖ_1 by integrating the fraction $\int \varpi_1 dv$ between those limits. Since $\varpi_1 = \frac{vp}{vp+wq}$, we have $\int \varpi_1 dv = \int \frac{pvdv}{vp+wq}$, which on substituting $1-v$ and $1-p$ for w and q respectively, becomes $\int \frac{pvdv}{1-p+(2p-1)v}$, the integral of which is

$$p\left\{\frac{v}{2p-1} - \frac{1-p}{(2p-1)^2}\log.\left(1-p+(2p-1)v\right)\right\} + C,$$

C being a constant, the value of which will be determined from the assumed limits. If v be supposed to vary between the limits $v=0$ and $v=1$, then

$$\int \varpi_1 dv = \frac{p}{2p-1}\left\{1 - \frac{1-p}{2p-1}\log.\frac{p}{1-p}\right\};$$

and if we assume $p=\frac{3}{4}$, we have $\int \varpi_1 dv = \frac{3}{2}(1-\frac{1}{2}\log.3)$, which, since the logarithm is the Napierian logarithm, and Nap. log. $3=1.0986$, becomes $\frac{3}{2} \times .4507 = .676$, or nearly $\frac{2}{3}$. Whence we see, that on this hypothesis the probability of the event is diminished in consequence of the testimony.

68. The credit due to the testimony of a witness depends not merely on his good faith, but also on the probability that he is not himself deceived with respect to the event he asserts. The chances of a witness being deceived through credulity or ignorance are much more numerous in general than the chances of intentional fraud; and this must be the case more particularly when the event is of such a nature that it may happen in various ways which may be mistaken one for another: as for instance, in the case of a lottery ticket being drawn, and the witness asserting that it bears a particular number, which might with equal probability be any other number on the wheel. The following question will illustrate the method of applying the calculus when a distinction is made between these sources of error.

An urn contains s balls, of which a_1 are marked A_1, a_2 marked A_2 ..... a_n marked A_n. A ball having been drawn at random, a witness of the drawing affirms that the ball drawn is marked A_m; required the probability of the testimony being true.

Here we have $s = a_1 + a_2 + a_3 \ldots\ldots + a_n$, ($n$ being the number of the different indices or sorts of balls); so that if we make $p_1 = a_1 \div s$, $p_2 = a_2 \div s \ldots\ldots p_n = a_n \div s$, then p_1 is the *a priori* probability that the ball drawn is of the class marked A_1, p_2 the probability that it belongs to the class whose index is A_2, and so on. It is evident that n different hypotheses may be made respecting the index of the ball which has been drawn, for it may belong to any one of the different classes A_1, $A_2 \ldots A_n$. Let the probabilities of these hypotheses be respectively $\varpi_1, \varpi_2 \ldots \varpi_n$, (that is, in respect of any particular index i, ϖ_i is the probability after the assertion that the ball drawn is marked A_i); and let the probabilities of the assertion on each of these hypotheses be respectively $P_1, P_2 \ldots P_n$, (that is, if the ball drawn be marked A_p then P_t is the probability the witness will assert it

Probability. to be marked A_m). Lastly, let v be the veracity of the witness, and u the probability that he has not been deceived.

(1.) Let us first consider the hypothesis that the ball drawn is marked A_m, and consequently that the assertion is true. In order to find P_m, the probability of the assertion being made, there are four cases to be considered. 1st, we may suppose the witness is not deceived himself (u), and that he speaks the truth (v). The probability of the assertion in this case is uv. 2d, The witness knows the truth, but intends to deceive, or testifies falsely. In this case the probability of the assertion being made, on the hypothesis under consideration, is 0. 3d, The witness has been deceived himself, but intends to speak the truth. In this case also the probability of the assertion being made is 0. 4th, The witness has been deceived himself, and intends to deceive. In this case the assertion might be made; and to find the probability of its being made we have to consider, that since the witness has been deceived, he must have supposed some other index than A_m to have been drawn; and since he intends to deceive, he must assert some other index to be drawn than that which he supposes to be drawn. Setting aside, therefore, the index which he supposes to have been drawn, there remain $n-1$ others, any one of which he is as likely to name as any other. The probability, therefore, of his naming A_m when he intends to deceive is $1\div(n-1)$. Hence the probability of the assertion in this case is compounded of the probabilities of three simple events, as follows: 1. Probability the witness is deceived $=(1-u)$; 2. Probability he intends to deceive $=(1-v)$; 3. Probability he names A_m $=1\cdot:(n-1)$. The probability of the assertion is therefore in this case $=(1-u)(1-v)\div(n-1)$. Adding this to the probability found in the first case, we have P_m, the whole probability of the assertion being made on the hypothesis that the index of the ball drawn was A_m, namely

$$P_m=uv+\frac{(1-u)(1-v)}{n-1}.$$

(2.) Let us now consider one of the remaining hypotheses, and suppose that the ball actually drawn was marked A_p, and not A_m, as attested by the witness. As before, there are four possible cases for consideration. 1st, The witness knows the fact and speaks the truth. In this case the assertion could not be made, or its probability is 0. 2d, The witness knows the fact, and intends to deceive. In this case the probability of his asserting A_m to be drawn is compounded of the probability that he is not deceived (u), the probability that he testifies falsely ($1-v$), and the probability that, knowing the index A_t to be drawn, he selects A_m from among the $n-1$ which remain after rejecting A_p ($1\div(n-1)$). The probability of the assertion being made in this case is therefore $u(1-v)\div(n-1)$. 3d, The witness is deceived, and intends to speak the truth. By reasoning as in the last case, it is easy to see that the probability of the assertion being made in this case is $v(1-u)\div(n-1)$. 4th, The witness is deceived, and intends to deceive. The probability of the assertion being made in this case will be found by considering, that as the witness is himself deceived, he must suppose some particular index to be drawn different from A_p (which is drawn by hypothesis), for instance A_σ, the probability of which is $1\div(n-1)$; and intending to deceive, he must fix on some index different from A_σ, which he supposes to be drawn; and he announces A_m, the probability of which selection is also $1\div(n-1)$. The probability, therefore, that the witness supposes A_ϵ to be drawn, and annnounces A_m, is $1\div(n-1)^2$. But it is evident, that whatever can be affirmed with respect to the particular index A_σ, may be affirmed with equal truth of every one of the other n indexes, excepting A_p which is actually drawn, (since by hypothesis the witness is deceived), and A_m, which he announces, (since by hypothesis he lies). There are therefore $n-2$ different ways in which he may at the same time be deceived, and intend to deceive, and announce A_m; consequently the probability of this announcement in any of these ways is $(n-2)\div(n-1)^2$. Multiplying this into the probability of his being deceived $(1-u)$, and the probability of his giving false testimony $(1-v)$, the probability of the assertion in this case becomes $\frac{(1-u)(1-v)(n-2)}{(n-1)^2}$. Hence the whole probability of the assertion, in all the cases included in the hypothesis that the ball actually drawn was marked A_p, is

$$P_i=\frac{u(1-v)}{n-1}+\frac{(1-u)v}{n-1}+\frac{(1-u)(1-v)(n-2)}{(n-1)^2}.$$

As this expression will evidently be the probability of the assertion on any other of the $n-1$ hypotheses that the ball actually drawn was marked with an index different from A_m, the sum of the probabilities of the assertion on all these hypotheses is ΣP_i, where i is successively each of the numbers 1, 2, 3,...n, excepting m.

We have now to find ϖ_m, the probability of the first hypothesis. Since the hypotheses, in the present question, are not all equally probable *a priori*, we must have recourse to the formula (49) $\varpi_i=\lambda_i P_i\div\Sigma\lambda_i P_i$ and consequently in the present case we have

$$\varpi_m=\frac{\lambda_m P_m}{\lambda_m P_m+\Sigma\lambda_i P},$$

the sign of summation Σ including every value of i from 0 to n, excepting $i=m$. Now the value of P_i being the same in respect of each of the hypotheses which suppose the assertion untrue, $\Sigma\lambda_i P_i=P_i\Sigma\lambda_i$; and the sum of all the values of λ_i from $i=0$ to $i=n$ being 1, on excluding $\lambda_m=a_m\div s$, we have $\Sigma\lambda_i=(s-a_m)\div s$. Substituting this, together with the values of P_m and P_p as above found, and making $u'=1-u$, $v'=1-v$, the formula becomes, after the proper reduction,

$$\varpi_m=\frac{a_m\{(n-1)uv+u'v'\}}{a_m\{(n-1)uv+u'v'\}+(s-a_m)\{u'v+uv'+\frac{n-2}{n-1}u'v'\}};$$

which is the probability of the hypothesis that a ball marked A_m was drawn, or that the testimony is true.

When there are no two balls in the urn having the same index, the numbers a_1, a_2, a_3, &c. become each $=1$, and $s=n$. In this case the formula gives

$$\varpi_m=\frac{(n-1)uv+u'v'}{(n-1)uv+u'v'+(n-1)(u'v+uv')+(n-2)u'v'},$$

which, on observing that $uv+u'v+uv'+u'v'=1$, becomes by reduction

$$\varpi_m=uv+\frac{(1-u)(1-v)}{n-1}.$$

This is the probability of the truth of the testimony of a witness, who affirms that the number m is drawn from an urn which contains n balls, numbered 1, 2, 3...n. It is obvious, that when u and v are fractions approaching to unity, and n is a considerable number, the second term becomes very small, and may be neglected. The probability then becomes simply $\varpi_m=uv$.

69. We now proceed to consider the probability of an event attested by several witnesses; and first let us suppose the witnesses to agree in their testimony. The measures of the veracity of the several witnesses being respectively v_1, v_2, v_3, &c., and the *a priori* probability of the event being p, we have by (58) for its probability after the testimony of the first witness,

$$\varpi_1=\frac{v_1 p}{v_1 p+(1-v_1)(1-p)}.$$

In order to find the probability of the event after the second witness gives his testimony, we may suppose the *a priori* probability to be changed from p to ϖ_1 by the testimony of the first witness, and the same formula gives

Probability. $\varpi_2 = \dfrac{v_2\varpi_1}{v_2\varpi_1+(1-v_2)(1-\varpi_1)} = \dfrac{v_1v_2p}{v_1v_2p+(1-v_1)(1-v_2)(1-p)}$.

Let a third witness now come forward, and give testimony in favour of the same event. Its probability after his testimony will become in like manner

$$\varpi_3 = \frac{v_3\varpi_2}{v_3\varpi_2+(1-v_3)(1-\varpi_2)} = \frac{v_1v_2v_3p}{v_1v_2v_3p+(1-v_1)(1-v_2)(1-v_3)(1-p)}.$$

In general, let ϖ^x be the probability of an event after it has been attested by x witnesses, and let v_x be the veracity of the last witness, then ϖ_{x-1} being the probability of the event after $x-1$ eyewitnesses have each testified in its favour, we have

$$\varpi_x = \frac{v_1v_2\ldots\ldots v_xp}{v_1v_2\ldots v_xp+(1-v_1)(1-v_2)\ldots(1-v_x)(1-p)}.$$

If we suppose the witnesses all equally credible, or that $v_1=v_2=v_3\ldots=v_x$, this becomes

$$\varpi_x = \frac{v_xp}{v^xp+(1-v)^x(1-p)} = \frac{1}{1+\left(\dfrac{1-v}{v}\right)^x\dfrac{1-p}{p}}.$$

Now, if $v=\frac{1}{2}$, then $(1-v)\div v=1$, and $\varpi_x=p$; whence it appears that the probability of an event is not increased by the testimony of any number of witnesses, when the veracity of each is only $\frac{1}{2}$; but when v is greater than $\frac{1}{2}$, the event becomes more probable as the number of witnesses is greater, and when v is a considerable fraction, its probability increases very rapidly with the number of witnesses.

70. When the values of v and p are given, that of x in the last formula may be found so as to render ϖ_x of any given value. Hence we may find the number of witnesses required to make it an even wager, whether an event exceedingly improbable, and in favour of which they give unanimous testimony, has happened or not. For example, let the odds against the event be a million million to one, that is, let $p=\dfrac{1}{1{,}000{,}000{,}000{,}001}=\dfrac{1}{10^{12}+1}$, and let v the veracity of each witness be $\dfrac{9}{10}$. In order that ϖ_x may equal $\frac{1}{2}$, we must have $\left(\dfrac{1-v}{v}\right)^x\dfrac{1-p}{p}=1$. Now $\dfrac{1-v}{v}=\dfrac{1}{9}$, and $\dfrac{1-p}{p}=10^{12}$, therefore $\left(\dfrac{1}{9}\right)^x\times10^{12}=1$; whence $x\log\dfrac{1}{9}=\log\dfrac{1}{10^{12}}$ or $x\log 9=12$ and therefore $x=\dfrac{12}{\cdot95424}=12{\cdot}6$ nearly, so that 13 independent witnesses would suffice to render it more probable that the event really took place than that it did not.

This example is given by Mr. Babbage, (Ninth Bridgewater Treatise, Note E), with a view to shew the fallacy of Hume's celebrated argument respecting miracles. What the example proves is simply this, that if we suppose an urn to contain a million million of white balls, and only one black ball, and that on a ball being drawn at random from the urn, thirteen eyewitnesses of the drawing, each of whom makes only one false statement in ten, without collusion, and independently of each other, affirm to A, who was not present at the drawing, that the ball drawn was black, then A would have rather a stronger reason for believing than for disbelieving the testimony. But it is sufficiently obvious, that the event attested in this case, though exceedingly improbable *a priori*, cannot be regarded as in any way miraculous. On the contrary, the black ball might be drawn with the same facility, and was *a priori* as likely to be drawn, as any other *specified* ball in the urn. Let it be granted that an event is within the range of fortuitous occurrence, Probability. and that there exists a single chance in its favour out of any number of millions of chances, it may then happen in any one trial; nay, a number of trials may be assigned, such that its non-occurrence would be many times more improbable than the contrary.

71. Let us next consider the case of a number of witnesses contradicting each other. If the first witness announces an event of which the probability is p, then the probability, after the testimony, of its having happened is ϖ_1, and the probability that it has not happened $1-\varpi_1$. Suppose a second witness now to appear, and testify that the event has not happened, and let the probability of the truth of his testimony be denoted by ϖ'_2; then $1-\varpi_1$ being the probability before his testimony was given that what he asserts is true, and v_2 being the measure of his veracity, we have, as in (69), $\varpi'_2=\dfrac{v_2(1-\varpi_1)}{v_2(1-\varpi_1)+(1-v_2)\varpi_1}$, whence, since $\varpi_1=\dfrac{v_1p}{v_1p+(1-v)(1-p)}$, there results

$$\varpi'_2 = \frac{(1-v_1)v_2(1-p)}{(1-v_1)v_2(1-p)+v_1(1-v_2)p}$$

for the measure of the probability that the event has not happened. The probability that it has happened is therefore $1-\varpi'_2$, and accordingly if ϖ'_2 be less than $\frac{1}{2}$, there is a stronger reason for believing that the event happened than that it did not. The method of forming the expression for the probability of the event, after it has been attested or denied by a third witness, or any number of successive witnesses, is obvious.

If we suppose the values of v_1 and v_2 to be equal, the expression becomes $\varpi'_2=1-p$, which is the *a priori* probability that the event did not happen. It is obvious that this must be the case, inasmuch as two contradictory testimonies of equal weight neutralize each other. In general, the probability of an event which is affirmed by m witnesses, and denied by n witnesses, all equally credible, is the same as that of an event which is affirmed by $m-n$ witnesses who agree in their testimony.

72. When a relation has been transmitted through a series of narrators, of whom the first only has a direct knowledge of the event, and each of the others derives his knowledge from the relation of the preceding, the probability of the event is diminished by every succeeding relation In order to obtain a general expression for the probability of traditionary testimony, we may take the event considered in (68), namely the extraction of a ball marked A_m from an urn containing s balls, of which a_1 are marked A_1, a_2 marked A_2,...a_n marked A_n, there being in all n different indices. Now suppose the relation to have passed through a chain of narrators, T, T_1, T_2,...T_x, in number $x+1$, of whom the first only was an eyewitness of the event, each of the others receiving his knowledge of it from the one preceding him, and communicating it in his turn to the succeeding, the question is to determine the probability that a ball marked A_m was drawn, after this event has been narrated by T_x, the last witness of the series.

73. In order to apply the general formula of (68) to this case, it is necessary to remark that the event observed is the attestation of T_x of his having been informed by T_{x-1} that the ball drawn from the urn, the drawing of which was seen by T, was marked A_m. There are n different hypotheses respecting the index of the ball actually drawn, but it is only necessary to consider two of them, namely, the hypothesis that the ball actually drawn was marked A_m, and any one of the other hypotheses which consist in supposing that a ball with a different index from A_m was drawn, for example A_r. Let the probability of the attestation, on the hy-

Probability. pothesis that the index of the ball drawn was A_m, be denoted by y_x, and its probability on the hypothesis that the index was A_t by y'_x, (y_x and y'_x corresponding to P_m and P_t in (68), which express the same probabilities in respect of the eyewitness T), then by (68), the probability of the hypothesis that A_m was drawn is

$$\varpi_m = \frac{\lambda_m y_x}{\lambda_m y_x + \Sigma \lambda_t y'_x}.$$

But since y'_x is the same for all the hypotheses that the index drawn was different from A_m, $\Sigma \lambda_t y'_x = y'_x \Sigma \lambda_t$; and by (68) $\Sigma \lambda_t = (s - a_m) \div s$, and $\lambda_m = a_m \div s$, therefore

$$\varpi_m = \frac{a_m y_x}{a_m y_x + (s - a_m) y'_x}.$$

We have now to find y_x and y'_x in terms of x. Let v, v_1, v_2, &c. be the respective probabilities of T, T_1, T_2, &c. speaking the truth, then the probability of T_x speaking the truth is v_x, and the probability that he does not $1 - v_x$, whether because he is dishonest, and intends to deceive, or because he has mistaken the statement of the preceding witness. Now there are two ways in which it may happen that A_m is announced by T_x. First, if he speaks the truth, and has been informed by the preceding narrator T_{x-1} that A_m was the index drawn; secondly, if he lies, and has been informed by T_{x-1} that a different index from A_m was drawn. Assuming y_{x-1} to have the same signification with respect to T_{x-1} that y_x has been assumed to have with respect to T_x, (that is to say, the probability of the assertion being made by T_{x-1} on the hypothesis that the ball actually drawn was A_m), the probability of the first of these combinations is $v_x y_{x-1}$. With respect to the second case, it is to be observed, that if T_x announces a different index from that which has been announced to him by T_{x-1}, the chance of his announcing A_m out of $n - 1$ indexes different from that announced by T_{x-1} is $1 \div (n - 1)$; and on multiplying this by the probability $1 - v_x$ that the testimony of T_x is false, and by the probability $1 - y_{x-1}$ that T_{x-1} has announced a different index from A_m, we have, for the probability of the second combination $(1 - v_x)(1 - y_{x-1}) \div (n - 1)$. The whole probability of T_x testifying that A_m was drawn, is therefore, on the first hypothesis, given by the equation,

$$y_x = v_x y_{x-1} + (1 - v_x)(1 - y_{x-1}) : (n - 1).$$

This is an equation of finite differences of the first order, the complete integral of which is

$$y_x = \frac{1}{n} + \frac{C(nv_1 - 1)(nv_2 - 1)\ldots(nv_{x-1} - 1)(nv_x - 1)}{(n - 1)^x}.$$

In order to determine the arbitrary constant C, it is to be observed, that, since y_1, $y_2 \ldots y_x$, as well as v_1, $v_2 \ldots v_x$ apply to the narrators T_1, $T_2 \ldots T_x$ respectively, if we suppose $x = o$ the resulting value of the integral will be the probability that A_m was announced by the eyewitness T, on the hypothesis that A_m was actually drawn. Let this probability be P_m; then the equation becomes $P_m = C + 1 \div n$ whence $C = (nP_m - 1) \div n$. If, therefore, we make.

$$X = \frac{(nv_1 - 1)(nv_2 - 1)\ldots(nv_{x-1} - 1)(nv_x - 1)}{(n - 1)^x}$$

we obtain, on the first hypothesis, for any value of x,

$$y_x = \{1 + (nP_m - 1)X\} \div n$$

In the same manner we find the probability y'_x of the testimony given by T_x, on the hypothesis that the ball actually drawn was A_r. The probability of the event, after being testified by the eyewitness, being on this hypothesis P_r we have,

$$y'_x = \{1 + (nP_r - 1)X\} \div n.$$

Substituting these values of y_x and y'_x in the expression Probability. above found for ϖ_m, we obtain for the probability of the event observed by T, and narrated by T_x, the narration having passed from one to another in the manner supposed,

$$\varpi_m = \frac{a_m\{1 + n(P_m - 1)X\}}{a_m\{1 + (nP_m - 1)X\} + (s - a_m)\{1 + (nP_r - 1)X\}}.$$

74. Since $\frac{nv_x - 1}{n - 1} = v_x - \frac{1 - v_x}{n - 1}$, and since v_x is always less than unity, and n always greater than unity, each of the terms of the series represented by X, whether positive or negative, is a proper fraction, whence the value of X becomes smaller and smaller as x increases. Suppose x infinite, then X = 0, and $\varpi_m = a_m \div s$, which is the *a priori* probability of the event. Hence we see that the probability of an event transmitted through a series of traditionary evidence becomes weaker at every step, and ultimately equal to the simple probability of the event, independent of any testimony.

75. When the urn is supposed to contain only n balls, each having a different index, the expression for ϖ_m is greatly simplified; for, in this case, $a_m = 1$, $s = n$; therefore, (since $P_m + (n - 1)P_t = 1$) the denominator becomes n, and we have consequently $\varpi_m = \{1 + (nP_m - 1)X\} \div n$, which coincides with the value of y_x found above, that is to say, with the probability of the event being testified by T_x on the hypothesis that it actually happened. Laplace, in solving this particular case of the problem, (p. 456) assumes that the probabilities here denoted by y_x and ϖ_m are identical. They are, however, as is evident from the above analysis, quite distinct in their nature, and their values are only equal in the particular case in which $s - a_m$ is to a_m in the ratio of $m - 1$ to 1. (Poisson, p. 112.)

76. The question of determining the probability that the verdict of a jury is correct, is precisely analogous to that of finding the probability of an event attested by one or more witnesses. Let us first take the case of a single juror, and assume $u =$ the probability that the juror gives a correct verdict, (that is, correct in respect of the facts), and $p =$ the probability that the accused is guilty before being put on his trial. Suppose the verdict guilty to be returned; two hypotheses may be made respecting the cause of the verdict, first, that the accused is guilty; secondly, that he is innocent. On the first hypothesis, the accused will be condemned if the juror gives a right verdict, the probability of which is u. On the second hypothesis, the accused will be condemned if the juror gives a wrong verdict, the probability of which is $1 - u$. But the *a priori* probabilities of these causes (the guilt or innocence of the accused) being respectively p and $1 - p$, we have by (49)

$$\varpi_1 = \frac{up}{up + (1 - u)(1 - p)}, \qquad \varpi_2 = \frac{(1 - u)(1 - p)}{up + (1 - u)(1 - p)},$$

ϖ_1 being the probability of the first hypothesis, or the probability that the accused is guilty after the verdict has been given, and ϖ_2 the probability resulting from the verdict that the accused is innocent.

77. Suppose the verdict not guilty to be given, and let ϖ'_1 and ϖ'_2 be the probabilities after the verdict of the two hypotheses. On the first hypothesis, namely, that the accused is guilty, this verdict will be given if the juror gives a wrong verdict, of which the probability is $1 - u$; and on the second hypothesis, the verdict will be given if the juror gives a right verdict, of which the probability is u; and the

[1] This is easily verified; for on changing x into $x - 1$ in the integral, and forming the expression $v_x y_{x-1} + (1 - v_x)(1 - y_{x-1}) \div (n - 1)$, there results an identical equation.

Probability. probabilities of these hypotheses before the verdict being respectively p and $1-p$ as before, we have

$$\varpi'_1=\frac{(1-u)p}{(1-u)p+u(1-p)}, \qquad \varpi'_2=\frac{u(1-p)}{(1-u)p+u(1-p)}.$$

From the above value of ϖ_1, we obtain $\varpi_1 - p = \frac{p(1-p)(2u-1)}{up+(1-u)(1-p)}$; a fraction which is positive or negative according as u is greater or less than $\frac{1}{2}$. Hence it appears that the guilt of the accused is only rendered more probable by the verdict guilty being pronounced, when the probability that the juror gives a correct verdict is greater than $\frac{1}{2}$. In like manner it is shewn that ϖ'_1 (the presumption of the guilt of the accused after a verdict of acquittal), is greater than p when u is less than $\frac{1}{2}$.

78. The *a priori* probability of the condemnation of the accused before he is put on his trial is $up+(1-u)(1-p)$; for there are two ways in which this condemnation may take place; first, if the accused be guilty, and the juror give a correct verdict, the probability of which concurrence is up; and, secondly, if the accused be innocent, and the juror give a wrong verdict, the probability of which is $(1-u)(1-p)$. Therefore, making $c =$ the probability of a verdict of condemnation, we have $c=up+(1-u)(1-p)$; and for a verdict of acquittal, $1-c=(1-u)p+u(1-p)$.

79. Let us next suppose that after the verdict of the first juror has been pronounced, the accused is put on his trial before a second juror, and let u_2 be the probability the second juror gives a correct verdict, and c_2 be the probability the accused will be pronounced guilty by him. After the verdict guilty has been pronounced by the first juror, the probability of the guilt of the accused is ϖ_1, and it is evident that c_2 will be found by substituting u_2 for u, and ϖ_1 for p in the above value of c, whence $c_2=u_2\varpi_1+(1-u_2)(1-\varpi_1)$. The probability of a verdict of condemnation by both jurors is cc_2; therefore, (observing that $\varpi_1=up\div c$), we have for this probability

$$cc_2=uu_2p+(1-u)(1-u_2)(1-p).$$

The probability of the guilt of the accused after a verdict of acquittal has been pronounced by the first juror being ϖ'_1, the probability of a verdict of acquittal being given by the second juror is $1-c_2=(1-u_2)\varpi'_1+u_2(1-\varpi'_1)$; therefore, (observing that $\varpi'_1=(1-u)p\div(1-c)$, we have for the probability of a verdict of acquittal by both jurors

$$(1-c)(1-c_2)=(1-u)(1-u_2)p+uu_2(1-p).$$

Adding the probability of a verdict of condemnation by both jurors, to that of acquittal by both, we have $uu_2+(1-u)(1-u_2)$ for the probability of both giving the same verdict. This result is independent of p, and is evidently true *a priori*, inasmuch as there are two ways in which the same verdict may be given, namely, when both jurors are right, and when both are wrong.

The probability of acquittal by the second juror, after a verdict of guilty by the first, is $1-c_2=(1-u_2)\varpi_1+u_2(1-\varpi_1)$; multiplying by c, and substituting for c and ϖ_1 their values, we have for the probability of a verdict of guilty by the first, and not guilty by the second,

$$c(1-c_2)=u(1-u_2)p+(1-u)u_2(1-p).$$

In like manner, if the accused has been acquitted by the first juror, the presumption of his guilt becomes ϖ'_1, and the probability of a verdict guilty by the second is $c_2=u_2\varpi'_1+(1-u_2)(1-\varpi'_1)$; therefore the probability of a verdict of not guilty by the first, and of guilty by the second is

$$(1-c)c_2=(1-u)u_2p+u(1-u_2)(1-p).$$

The sum of these two expressions gives for the probability of a discordant verdict, $u(1-u_2)+(1-u)u_2$.

80. If we now suppose $u=u_2$, and make $1-u=w$, the probability that the two jurors will agree in their verdict, whether they are both right or both wrong, is u^2+w^2; and the probability of a discordant verdict $uw+uw=2uw$. The sum of the two expressions is $u^2+2uw+w^2=(u+w)^2$; and therefore the probabilities of the different cases are respectively given by the development of the binomial $(u+w)^2$. Probability.

By pursuing this reasoning, it is easy to see that if there be any number h whatever of jurors, or voters on any question which admits only of simple affirmation or negation, all being supposed to possess the same integrity and knowledge, so that there is the same probability u of a correct decision in respect of each, the probablities of the different cases are found by the development of the binomial $(u+w)^h$. The probability of a correct verdict being pronounced unanimously is u^h; of an erroneous one being pronounced unanimously is w^h; and the probability that a correct verdict will be given by m of the jurors, and an erroneous one by n, is Uu^mw^n, where $U=\frac{1.2.3.....h}{1.2.3...m\times 1.2.3...n}$.

81. The probability that the accused will be pronounced guilty by m jurors, and acquitted by n, on the supposition that the value of u is the same for each juror, is thus found. There are two ways in which this event may take place; 1st, if the accused be guilty (the probability of which is p), and m jurors decide correctly, and n wrongly (the probability of which is Uu^mw^n); the probability of the condemnation taking place in this way is therefore Uu^mw^np. 2d, If the accused be innocent (the probability of which is q) and n jurors decide rightly, and m wrongly (the probability of which is Uu^nw^m); the probability of the event taking place in this way is therefore Uu^nw^mq. Let G therefore denote the whole probability of the verdict, and we have

$$G=U(u^mw^np+u^nw^mq).$$

Hence the probability that the accused will be condemned unanimously by a jury consisting of h jurors is u^hp+w^hq; and the probability that he will be unanimously acquitted u^hq+w^hp.

82. Suppose the accused to have been pronounced guilty by m jurors, and not guilty by n jurors, the probability of the verdict of the majority being correct is found from the formula in (49). Two hypotheses may be made: 1st, the accused is guilty; 2d, he is innocent. The probability P_1 of the observed event (the condemnation by m, and acquittal by n jurors) on the first hypothesis is Uu^mw^n; and the *a priori* probabilities of the two hypotheses (or the probabilities denoted by λ_1 and λ_2 in (49), being p and q; therefore if ϖ_1 denote the probability of the verdict being correct, that is, the probability of the first hypothesis after the verdict has been pronounced, and ϖ_2 the probability of its being wrong, we shall have (49)

$$\varpi_1=\frac{u^mw^np}{u^mw^np+u^nw^mq}, \qquad \varpi_2=\frac{u^nw^mq}{u^mw^np+u^nw^mq}.$$

If the verdict has been pronounced unanimously, then $m=h$ and $n=0$, and the formulæ become

$$\varpi_1=\frac{u^hp}{u^hp+w^hq}, \qquad \varpi_2=\frac{w^hq}{u^hp+w^hq}.$$

If $p=q=\frac{1}{2}$, and $m-n=i$, we have then

$$\varpi_1=\frac{u^{n+i}w^n}{u^{n+i}w^n+u^nw^{n+i}}=\frac{u^i}{u^i+w^i}.$$

But this is the probability of a verdict being correct which has been pronounced unanimously by i jurors; whence it follows that the probability of a decision rendered by a given majority being correct, is the same as that of a decision rendered unanimously by a jury equal in number to the difference between the majority and minority, and is therefore independent of the total number of jurors. This, however, is only true on the supposition that the value of u is known *a priori*; for if u be not absolutely known, the weight of the

Probability. verdict depends on the ratio of the majority to the whole number of jurors. This is in accordance with common notions, for it will readily be admitted that a verdict given unanimously by a jury of 10 will be entitled to much more weight than one pronounced by a jury consisting of a large number, as 100, in which 55 are of one opinion, and 45 of the opposite. In this case, the opinion of the minority throws great doubt on the correctness of the verdict. It is to be observed, however, that the probability of a verdict being given by a small majority becomes less and less as the number of jurors is increased.

83. When the number who dissent from the opinion of the majority is unknown, and we merely know that the majority exceeds the minority by *at least i* jurors, the probability of the verdict being correct is found as follows. Suppose the verdict to be guilty. On the hypothesis that it is correct, the probability of the accused being found guilty by $h-x$, and not guilty by x jurors, is by the formula in (80), $Uu^{h-x}w^x$. Now, if we give x successively all the values 0, 1, 2,...n, where $n=\frac{1}{2}(h-i)$, and assume U_0 to denote the value of U when $x=0$, U_1 its value when $x=1$, and so on; and also make W=the probability of the accused being pronounced guilty by $h-n$ *at least*, we shall have

$$W=U_0u^h+U_1u^{h-1}w+U_2u^{h-2}w^2.....+U_nu^{h-n}w^n.$$

In like manner, if W′ denote the probability of a verdict guilty by $h-n$ jurors *at least*, on the hypothesis that the accused is not guilty, we shall have,

$$W'=U_0w^h+U_1uw^{h-1}+U_2u^2w^{h-2}.....+U_nu^nw^{h-n};$$

whence, p and q being as above the *a priori* probabilities of the two hypotheses, the probability that the verdict guilty is correct, when pronounced by $h-n$ jurors at least, becomes $Wp\div(Wp+W'q.)$

84. It is evident that no application can be made of these formulæ without assigning arbitrary values to u and p, unless, indeed, we have data for determining their mean values from experience. With respect to p, we may assume, for the sake of shewing the general consequences of the formulæ, its value to be $\frac{1}{2}$; for it cannot well be supposed less than $\frac{1}{2}$, or that a person brought before a jury is more likely to be innocent than guilty; and if it much exceeds $\frac{1}{2}$ and approaches to unity, a verdict of guilty may be expected from any jury, however constituted. When a mean value of u cannot be determined from experience, the only way of obtaining numerical results, is to suppose u to have all possible values within given limits, and to integrate the equations between those limits. As it seems unreasonable to suppose that a juror is more likely to give a wrong verdict than a right one, we may assume that u cannot be less than $\frac{1}{2}$. Suppose, then, that u increases by infinitely small increments from $u=\frac{1}{2}$ to $u=1$, and let it be proposed to determine the probability that a decision is correct when the accused has been pronounced guilty by m jurors, and not guilty by n. Here an infinite number of hypotheses may be made respecting the value of u, and we must therefore have recourse to the formulæ in (51.) Let $u=x$ be one of those hypotheses, $P_x=$ the probability on that hypothesis of the event observed (that is, of the accused being pronounced guilty by m, and not guilty by n jurors,) $\varpi_x=$ the probability of the assumed hypothesis, and $\Pi=$ the mean probability of the correctness of the verdict from all the hypotheses. By the formulæ in (81) we have

$$P_x=U\{x^m(1-x)^np+x^n(1-x)^m(1-p)\},$$

and as all the hypotheses are supposed equally probable, we have (45) $\varpi_x=P_x\div\Sigma P_x$. But between the proposed limits $\Sigma P_x=p\int_{\frac{1}{2}}^1x^m(1-x)^ndx+(1-p)\int_{\frac{1}{2}}^1x^n(1-x)^mdx$; if, therefore, we make $p=\frac{1}{2}$, we shall have by reason of $\int_{\frac{1}{2}}^1x^n(1-x)^mdx=\int_{\frac{1}{2}}^1x^m(1-x)^ndx$, $\Sigma P_x=\frac{1}{2}\int_0^1x^m(1-x)dx$, and therefore

$$\varpi_x=\frac{x^n(1-x)^n+x^m(1-x)^m}{\int_0^1x^m(1-x)^ndx},$$

Probability.

for the probability of the hypothesis. But (82) the probability on this hypothesis of the accused being guilty, is $\frac{x^m(1-x)^n}{x^m(1-x)^n+x^n(1-x)^m}$; multiplying this by the probability of the hypothesis, ϖ_x, we obtain for the probability of the verdict being correct $x^m(1-x)^n\div\int_0^1x^m(1-x)^ndx$; and, therefore, for the probability of the verdict being correct on all the hypotheses from $x=\frac{1}{2}$ to $x=1$,

$$\Pi=\frac{\int_{\frac{1}{2}}^1x^m(1-x)^ndx}{\int_0^1x^m(1-x)^ndx}.$$

Hence the probability that a verdict given by a majority m out of $m+n=h$ jurors is wrong, is

$$1-\Pi=\frac{\int_0^{\frac{1}{2}}x^m(1-x)^ndx}{\int_0^1x^m(1-x)^ndx},$$

which, on effecting the integrations by the formula in (51) becomes after reduction

$$1-\Pi=\frac{1}{2^{h+1}}\left\{1+\frac{h+1}{1}+\frac{(h+1)h}{1\cdot2}+\frac{(h+1)h(h-1)}{1\cdot2\cdot3}.....+\frac{(h+1)h(h-1).....(h-n+2)}{1\cdot2\cdot3.....n}\right\}.$$

Assuming h (the number of jurors) $=12$, and making n successively 0, 1, 2, 3, 4, 5, the series gives

$$\frac{1}{8192},\ \frac{14}{8192},\ \frac{92}{8192},\ \frac{378}{8192},\ \frac{1093}{8192},\ \frac{2380}{8192}$$

for the respective probabilities of the error of a verdict when pronounced unanimously by 12 jurors, by a majority of 11 to 1, of 10 to 2, of 9 to 3, of 8 to 4, and of 7 to 5. In the last case the probability of the error is nearly $=\frac{2}{7}$.

85. From these results it appears that the chance of a verdict being wrong which has been pronounced unanimously by twelve jurors is very small; but it is to be remarked, that they have been deduced on the supposition that the unanimity proceeds from agreement in the same opinion, and that the jurors are unbiassed by each other. In this country, where unanimity is compelled by law, the mean probability of a correct verdict can scarcely be considered as greater than that of a verdict pronounced by a simple majority; for, though in most cases the verdict may be supposed to represent the opinion of a larger majority than seven, it may happen, not unfrequently, that a smaller number than five, possessing greater energy or perseverance, may persuade the others into a surrender of their judgment. In fact, unless the presumption of the guilt of the accused be very great, it would scarcely be possible, without concert, to procure an unanimous verdict in any case. It is also to be observed, that the assumption of all values of u from $\frac{1}{2}$ to 1 being equally probable, may lead to results widely different from the truth. The mean value of u, which depends on the general intelligence of the class of persons from amongst whom the lists of jurors are made up, can only be rightly determined from data furnished by experience. One of the elements, however, which require to be known for this purpose, is the number of jurors who concur in and dissent from, the verdict. The forced unanimity of the law renders it impossible to obtain this element from the records of the English courts; but in France and Belgium, where the majority and minority are known and recorded, the same obstacle does not exist, and the "*Comptes Généraux de l'Administration de la Justice Criminelle*," published by the French Government, have enabled Poisson to deduce mean values of u and p for that country, and consequently to obtain the necessary data for one of the most interesting applications of the theory of Probabilities. The general results were as follows: During

Probability. the six years from 1825 to 1830 inclusive, the system of criminal legislation in France underwent no change; the jury consisted of 12, and a simple majority was only required to concur, though when it happened that the majority was the least possible, the Court had power to overrule the verdict. On comparing, according to the rules of the theory, the verdicts given in the cases tried before the criminal courts during those six years, it was found that for the whole of France, the probability (u) of a juror giving a correct verdict was a little greater than $\frac{2}{3}$ with respect to crimes against the person, and nearly equal to $\frac{13}{17}$ with respect to crimes against property; without distinction of the species of crime, it was found to be a very little below $\frac{3}{4}$. The other element, the probability (p) of the guilt of the accused before the trial, was found not much to exceed $\frac{1}{2}$ (being between 0.53 and 0.54) with respect to crimes against the person, while it a little exceeded $\frac{2}{3}$ in respect of crimes against property. Without distinction of crime, its value was very nearly 0.64.

86. On substituting these values of u and p (namely $u=\frac{3}{4}$, $p=.64$, whence $w=\frac{1}{4}$, $q=.36$) in the formula in (81), and making $m=7$, $n=5$, and consequently

$$U=\frac{1\,.\,2\,.\,3\ldots\ldots12}{1\,.\,2\,.\,3\ldots7\times1\,.\,2\,.\,3\ldots5}=792,\quad\text{we have}\quad G=\frac{792}{4^{12}}(3^7\times.64+3^5\times.36)=.07$$

nearly. Hence it may be expected, that in a hundred trials it will happen only seven times that the accused will be pronounced guilty by the smallest possible majority. If $m=12$, and $n=0$, we shall have $u^hp+w^hq=.02027=\frac{1}{50}$ nearly, for the probability of an unanimous verdict of guilty, and $u^hq+w^hp=.0114$ for the probability of an unanimous verdict of not guilty.

Making the same substitutions in the formula in (82), we have for the probability of a verdict guilty being correct, from which 5 jurors out of 12 dissent, $\varpi_1=\frac{16}{17}$; and $\varpi_2=\frac{1}{17}$ for the probability of its being wrong.

Substituting the same values in the series represented by W and W′ in (83), and supposing n to have all values from $n=0$ to $n=5$, there results $W=\frac{3^7}{4^{12}}\times7254$, $W'=\frac{1}{4^{12}}\times239122$, whence $\frac{Wp}{Wp+Wq}=\frac{126915984}{127992033}=\frac{118}{119}$ nearly. This is the probability that a verdict guilty, pronounced by a majority of seven against five *at least*, is correct. The probability of the same verdict being wrong, is therefore $\frac{1}{119}$; so that out of 119 verdicts, respecting which we know nothing else, than that seven at least of the jury concurred in finding the accused guilty, we may expect one to be wrong, or that one person out of 119 so condemned will be innocent.

SECT. VIII. OF THE SOLUTION OF QUESTIONS INVOLVING LARGE NUMBERS.

87. The probabilities of the different compound events which can result from the combination of any number of simple events, E_1, E_2, E_3, &c. being (13) measured respectively by the several terms of the developement of the multinomial $(p+q+r+\&c.)^h$, the most probable of those compound events will be that which corresponds to the term having the greatest numerical value. Let us consider the case of two simple contrary events E and F, the probabilities of which are respectively p and q, and suppose the number of occurrences to be 4. Neglecting the order of occurrence, the different combinations, with their respective probabilities, are the following:

EEEE, EEEF, EEFF, EFFF, FFFF,
p^4, $4p^3q$, $6p^2q^2$, $4pq^3$, q^4.

Now it is evident that the numerical values of these probabilities depend on the ratio of p to q, as well as on the coefficient by which they are multiplied, and that values may be given to p and q, such that any one of the terms may be made the greatest or the least in the series. If we suppose Probability. $p=q$, and consequently $p=\frac{1}{2}$, $q=\frac{1}{2}$, (since $p+q=1$) the probabilities of the different cases become respectively

$$\frac{1}{16},\quad\frac{4}{16},\quad\frac{6}{16},\quad\frac{4}{16},\quad\frac{1}{16};$$

whence it appears, that the most probable combination is that which corresponds to $6p^2q^2$, or in which each of the simple events occurs twice, the probability of this combination being $\frac{6}{16}$, while that of either of the simple events occurring four times in succession is only $\frac{1}{16}$.

When the number of trials is 5, the probabilities of the several cases are respectively

$$p^5,\quad5p^4q,\quad10p^3q^2,\quad10p^2q^3,\quad5pq^4,\quad q^5,$$

which, when $p=q$, become

$$\frac{1}{32},\quad\frac{5}{32},\quad\frac{10}{32},\quad\frac{10}{32},\quad\frac{5}{32},\quad\frac{1}{32},$$

so that there are two different combinations equally probable, namely, that in which E occurs three times and F twice, and that in which E occurs twice and F three times; and of the six possible combinations these two are the most probable, having in their favour a number of chances twice as great as the two cases in which one of the events occurs only once, and the other four times, and ten times greater than the two cases in which either of the simple events occurs in each of the five trials.

From these two instances it may be inferred in general, that when h is an even number, the most probable compound event is that of which the probability is represented by the middle term of the developement of $(p+q)^h$; and that when h is an odd number, there are two compound events equally probable, and more probable than any other, namely, those corresponding to the terms which occupy the middle of the series, supposing in both cases $p=q$. This supposition gives $(p+q)^h=(1+1)^h(\frac{1}{2})^h$; therefore in the case in which h is an even number, the general expression for the greatest term is

$$\frac{h(h-1)(h-2)\ldots\ldots(h-\frac{1}{2}h+1)}{1\,.\,2\,.\,3\quad\ldots\ldots\quad\frac{1}{2}h}(\tfrac{1}{2})^h;$$

and when h is odd, the general expression for either of the two equal terms, which are greater than any of the other terms, is

$$\frac{h(h-1)(h-2)\ldots\ldots\{h-\frac{1}{2}(h+1)+1\}}{1\,.\,2\,.\,3\quad\ldots\ldots\quad\frac{1}{2}(h+1)}(\tfrac{1}{2})^h.$$

88. When p and q are unequal, the greatest term of the expansion of $(p+q)^h$ will not occupy the middle of the series, but its place may be found by comparing two consecutive terms. Let $h=m+n$. The general term of the series then becomes

$$\frac{1\,.\,2\,.\,3\ldots\ldots h}{1\,.\,2\,.\,3\ldots\ldots m\times1\,.\,2\,.\,3\ldots\ldots n}p^mq^n;$$

and the term immediately preceding is

$$\frac{1\,.\,2\,.\,3\ldots\ldots h}{1\,.\,2\,.\,3\ldots\ldots(m+1)\times1\,.\,2\,.\,3\ldots\ldots(n-1)}p^{m+1}q^{n-1}.$$

Dividing the first of these by the second, we get for the quotient $(m+1)q\div np$, which, therefore, is the ratio of two consecutive terms taken at any part of the series. If this ratio be greater than 1, the term which has been taken as the dividend is greater than the preceding one which has been taken as the divisor; and it is evident that the terms must go on increasing, from the beginning of the series, so long as the ratio in question is greater than 1. But if the ratio be less than 1, the preceding term is greater than the succeeding, and the terms will become less and less as they are nearer the end of the series. Let $(m+1)q\div np=1$; then, since $p+q=1$, and $m+n=h$, we have $n=(h+1)q$, and consequently the ratio of any term to the next preceding is greater or less than 1 according as n is less or greater than $(h+1)q$. Now n is necessarily a whole number; therefore if $(h+1)q$ be a whole number, take $n=(h+1)q$, and the two terms of the series given by the expansion

Probability. of $(p+q)^h$, in which the exponents of q are $n-1$ and n, will be equal to each other, and each greater than any other term of the series. But if $(h+1)q$ be not a whole number, let $(h+1)q-x$ be the nearest whole number *less* than $(h+1)q$, and make $n=(h+1)q-x$; then the greatest term of the developement will be that in which the exponent of q is n.

Since $n=(h+1)q-x$, we have $q=(n+x)\div(h+1)$, whence $p=1-\frac{n+x}{h+1}=\frac{m+1-x}{h+1}$, and therefore $\frac{q}{p}=\frac{n+x}{m+1-x}$. Now x is by hypothesis less than 1, therefore if m and n are large numbers, we have, very nearly, $q:p=n:m$; or, since $m+n=h$, $m=hp$, $n=hq$. It follows therefore, that the greatest term of the developement of the binomial $(p+q)^h$ is that in which the exponents of p and q are to each other in the ratio of p to q, or more nearly in that ratio than are any other two numbers whose sum is h. In other words, the most probable combination of two simple events, E and F, in any number of trials, is that in which the number of occurrences of E is to the number of occurrences of F in the ratio of their respective probabilities.

89. In the same manner it may be shewn, that when there are more than two simple events, of which one must occur in every trial, the most probable result of any number of trials is that combination in which the number of repetitions of each simple event is in proportion to its probability in a single trial. Thus, the probabilities of the simple events being respectively p, q, r, &c. the most probable compound event is that whose probability is expressed by that term of the expansion of $(p+q+r+\&c.)^h$, which has for its argument p^{hp}, q^{hq}, r^{hr}, &c.

90. Having determined the form of the greatest term of the series, we have next to find a method of approximating to its numerical value; for its coefficient containing the product of the natural numbers from 1 to h inclusive, its direct calculation becomes impracticable even when h is only a moderately large number. The theorem which gives the approximate value of this product is known by the name of *Stirling's Theorem*, having been discovered by that mathematician. As its investigation is a matter of pure analysis, we shall not stop to give it here, but refer the reader to the *Treatise on Differences and Series*, by Sir John Herschel, in the translation of Lacroix's *Elementary Treatise on the Differential and Integral Calculus*, p. 568.[1] The theorem is as follows: Let x be any number, then

$$1\,.\,2\,.\,3\,.\,.\,.\,.\,.x=x^xe^{-x}\sqrt{2\pi x}\left(1+\frac{1}{12x}+\frac{1}{288x^2}+\&c.\right)$$

where e is the number of which the Napierean logarithm is unit, or the number 2·71828, and π the ratio of the circumference of a circle to the diameter, or 3·14159.

When x is a large number, the term divided by $12x$ becomes very small, and the series within the brackets may be considered as equal to unity. In this case, then, the formula becomes

$$1\,.\,2\,.\,3\,.\,.\,.\,.\,.x=x^xe^{-x}\sqrt{2\pi x},$$

which gives a sufficient approximation in most cases. If, for example, $x=1000$, the result will be within a 12000th part of the truth.

Now, let E and F be two events of such a nature that the one or the other must happen in every trial; let p and q be their respective probabilities, and P the probability that in $m+n=h$ trials, E will happen m times and F n times; then by (12) we have

$$P=\frac{1\,.\,2\,.\,3\,.\,.\,.\,.\,.\,.h}{1\,.\,2\,.\,3\,.\,.\,.\,.\,.m\times 1\,.\,2\,.\,3\,.\,.\,.\,.\,.n}p^mq^n.$$

When m, n, and h are large numbers, the value of this Probability. coefficient may be computed from the above formula, which gives

$$1\,.\,2\,.\,3\,.\,.\,.\,.\,.h=h^he^{-h}\sqrt{2\pi h},$$
$$1\,.\,2\,.\,3\,.\,.\,.\,.\,.m=m^me^{-m}\sqrt{2\pi m},$$
$$1\,.\,2\,.\,3\,.\,.\,.\,.\,.n=n^ne^{-n}\sqrt{2\pi n},$$

whence

$$P=\frac{h^he^{-h}\sqrt{h}}{m^mn^ne^{-(m+n)}\sqrt{(2\pi mn)}}p^mq^n=\left(\frac{hp}{m}\right)^m\left(\frac{hq}{n}\right)^n\sqrt{\frac{h}{2\pi mn}}.$$

This expression represents any term of the series $(p+q)^h$. The greatest term, which corresponds to the most probable result, is (88) that in which m and n are to each other in the ratio of p to q, or when $m=hp$, and $n=hq$. Let the greatest term therefore be denoted by P_o, that is to say, let P_o be the chance of the most probable result of h trials, and we shall have

$$P_o=\sqrt{(h\div 2\pi mn)},\text{ or }P_o=\sqrt{(1\div 2\pi hpq)}.$$

This last formula shews that the absolute probability of that combination which has the greatest number of chances in its favour becomes less and less as the number of trials is increased; for the fraction $1\div h$, to the square root of which the probability is proportional, diminishes as h is increased.

91. As an example, suppose a shilling to be tossed 100 times in succession. In this case $p=q=\frac{1}{2}$, $hp=50$, $hq=50$, and the most probable result of the trials is 50 times head and 50 times tail. We have then $h=100$, $m=50$, and $\sqrt{(h\div 2\pi mn)}=1\div\sqrt{(50\pi)}$ for the measure of the probability that the event will happen in this way exactly. On calculation, this is found $=.07979$; whence it appears, that although 50 heads and 50 tails is a more probable result of 100 trials than any other combination which can be named, its absolute probability is measured by a very small fraction. The probability of the contrary event, or that there will not be thrown 50 heads and 50 tails exactly, is $1-.07979=.92021$, so that the odds against the event are about 92 to 8, or 23 to 2. Had the number of trials been 1000, the probability of 500 times head and 500 times tail exactly, though more likely to occur than any other combination, would have been found $1\div\sqrt{(500\pi)}$; that is to say, $\sqrt{10}$ times, or rather more than 3 times less than in the former case. In general, when the chances in favour of the simple events are equal, the probability of the combination which is more likely to happen than any other, is inversely proportional to the square root of the number of trials.

92. The formulæ in (90) enable us also to determine the ratio of the greatest term of the developement of $(p+q)^h$ to any other term of the series, and consequently the relation of the probabilities of the different compound events. Let $m:n::p:q$, whence $m=hp$ and $n=hq$, and let P_x denote the probability that in h trials the event E will occur $(m-x)$ times, and the event F $(n+x)$ times, the probabilities of the simple events E and F being respectively p and q. By (13) we have

$$P_x=\frac{1\,.\,2\,.\,3\,.\,.\,.\,.\,.\,.h}{1\,.\,2\,.\,3\,.\,.\,.\,.\,.(m-x)\times 1\,.\,2\,.\,3\,.\,.\,.\,.\,.(n+x)}p^{m-x}q^{n+x},$$

which by (90) becomes

$$P_x=\frac{h^he^{-h}\sqrt{(2\pi h)}}{(m-x)^{m-x}e^{-(m-x)}\sqrt{2\pi(m-x)}\times(n+x)^{n+x}e^{-(n+x)}\sqrt{2\pi(n+x)}}\times p^{m-x}q^{n+x};$$

whence, substituting $m\div h$ for p, and $n\div h$ for q, and leaving out the factors common to the numerator and denominator, we find,

$$P_x=\sqrt{\left(\frac{h}{2\pi}\right)}(m-x)^{-m+x-\frac{1}{2}}(n+x)^{-n-x-\frac{1}{2}}m^{m-x}n^{n+x}.$$

[1] Stirling's investigation of the theorem, or rather of its equivalent, to find the sum of the logarithms of a series of numbers in arithmetical progression, is given in his *Methodus Differentialis*, p. 135.

Probability. Now $\log(m-x)^{-m+x-\frac{1}{2}}=(-m+x-\frac{1}{2})\log(m-x)$; and

$$\log(m-x)=\log m-\frac{x}{m}-\frac{x^2}{2m^2}-\&c.$$

therefore $\log(m-x)^{-m+x-\frac{1}{2}}=$

$$(-m+x-\tfrac{1}{2})\log m-(-m+x-\tfrac{1}{2})\left(\frac{x}{m}+\frac{x^2}{2m^2}+\&c.\right);$$

whence, neglecting terms divided by m^2, m^3, &c., m being supposed to be a large number in comparison with x,

$$\log(m-x)^{-m+x-\frac{1}{2}}=(-m+x-\tfrac{1}{2})\log m+x-\frac{x^2}{2m}+\frac{x}{2m};$$

therefore, on passing to numbers,

$$(m-x)^{-m+x-\frac{1}{2}}=m^{-m+x-\frac{1}{2}}\times e^{x-\frac{x^2}{2m}}\times e^{\frac{x}{2m}};$$

or, since $e^{\frac{x}{2m}}=1+\frac{x}{2m}+\frac{x^2}{2.4m^2}+\&c.$

$$(m-x)^{-m+x-\frac{1}{2}}=m^{-m+x-\frac{1}{2}}e^{x-\frac{x^2}{2m}}\left(1+\frac{x}{2m}\cdots\right).$$

In like manner, by changing m into n, and x into $-x$, we get

$$(n+x)^{-n-x-\frac{1}{2}}=n^{-n-x-\frac{1}{2}}e^{-x-\frac{x^2}{2m}}\left(1-\frac{x}{2n}\cdots\right).$$

Multiplying the first of these two expressions by m^{m-x}, and the second by n^{n+x}, we have

$$(m-x)^{-m+x-\frac{1}{2}}\times m^{m-x}=m^{-\frac{1}{2}}e^{x-\frac{x^2}{2m}}\left(1+\frac{x}{2m}\cdots\right)$$

$$(n+x)^{-n+x-\frac{1}{2}}\times n^{n+x}=n^{-\frac{1}{2}}e^{-x-\frac{x^2}{2n}}\left(1-\frac{x}{2n}\cdots\right),$$

whence, substituting these values in that of P_x, and neglecting the quantity divided by mn,

$$P_x=\sqrt{\left(\frac{h}{2\pi mn}\right)}e^{-\frac{x^2}{2m}-\frac{x^2}{2n}}=\sqrt{\left(\frac{h}{2\pi mn}\right)}e^{-\frac{hx^2}{2mn}}.$$

The term of the series $(p+q)^h$ which corresponds to this value of P_x is that which is x places to the right of the greatest term; and it has been shewn, (90), that the greatest term has for its expression $\sqrt{(h\div 2\pi mn)}$; therefore the greatest term being denoted, as before, by P_o, and the term which comes after it x places by P_x, we have

$$P_x=P_o e^{-hx^2\div 2mn},$$

that is to say, the probability the event E will happen m times and fail n times in $m+n$ trials, is to the probability of its happening $(m-x)$ times and failing $(n+x)$ times in the ratio of 1 to $e^{-hx^2\div 2mn}$.

Since the numbers m and n enter symmetrically into the expression $e^{-hx^2\div 2mn}$, it is evident that the result would have been the same if, instead of seeking the ratio of the greatest term to that which succeeds it by x places, we had sought the ratio of the greatest term to that which precedes it by x places. Hence if the most probable result of $m+n$ trials be that E will happen m times and fail n times, the probability that it will happen $m-x$ times and fail $n+x$ times is the same as the probability that it will happen $m+x$ times and fail $n-x$ times.

The following example will suffice to shew the application of the formula: A die is thrown 6000 times, required the probability that the number of aces turned up will be exactly 960?

Here p, the chance of throwing ace, is $\frac{1}{6}$, $q=\frac{5}{6}$, and $h=6000$; whence $m=hp=1000$, and $n=hq=5000$. We have first to find P_o, the chance of the most probable result, or of 1000 aces. By (90), $P_o=\sqrt{(h\div 2\pi mn)}$; whence, substituting the above values, $P_o=\sqrt{3}\cdot\sqrt{(5000\times 3.14159)}$. On performing the operation indicated by the logarithmic tables, we get $\log P_o=8.14050$, whence $P_o=.0138$.

The calculation of $e^{-hx^2\div 2mn}$ is as follows: Assume $t^2=hx^2\div 2mn$. We have $x=1000-960=40$. Probability.

$\log 40=1.60206$
2
3.20412
$\log h=\log 6000=3.77815$
$\log hx^2=6.98227$
$\log 2mn=\log 10{,}000{,}000=7$
$\log t^2=9.98227$
$\log e=.43429$, $\log .43429=9.63778$
$\log(t^2\times .43429)=9.62005$
$t^2\times .43429=t^2\log e=\ .41692$
$-t^2\log e=9.58308$
add $\log P_o=8.14050$
$\log P_x=7.72358$

therefore $P_x=.0053$, which is the chance of 960 aces exactly. The odds against this event are therefore 9947 to 53, or nearly 188 to 1.

93. When h, m, and n are large numbers, and x is small, the exponential $e^{-hx^2\div 2mn}$ differs little from unity, and it decreases slowly as x increases, so long as x is small in comparison of m and n. Suppose $m=n$ and $x=\sqrt{m}$, it becomes $e^{-1}=\frac{1}{e}=\frac{1}{2.7182818}$; so that if we assume $m=100$, the 10th term before or after the greatest would still exceed the 3d part of the greatest. But when x becomes greater than $\sqrt{m}$ or $\sqrt{n}$ the exponential, and consequently also the terms which are multiplied by it, begin to diminish with great rapidity, and the diminution is more rapid as x increases. If $m=n=100$, and $x=50$, then the exponent $hx^2\div 2mn=25$, so that $e^{-hx^2\div 2mn}=1\div e^{25}$, a quantity which is altogether insensible. We may therefore conclude generally that when h is a large number, the principal terms of the developement of $(p+q)^h$ are those which are near the greatest term, and that h may be taken so large that the terms towards the beginning or end of the series may at length become smaller than any assignable quantity.

94. From the proposition which has now been demonstrated it follows, that although the probability of that particular compound event which has the greatest number of chances in its favour is very small when the number of trials is great, yet on account of the rapid diminution of the terms towards the beginning and end of the series, the sum of a comparatively small number of terms taken on both sides of the greatest, may be very much greater than all the remaining terms of the series; and, consequently, there will be a very great probability that the compound event will be represented by one or other of those terms. This consideration leads us to one of the most important questions in the theory, namely, to determine the probability that in a large number of trials, h, an event E, which must either happen or fail in each trial, and of which the chance of happening in any trial is p, will happen not less than $hp-l$ times, and not oftener than $hp+l$ times; or, making $hp=m$, $hq=n$, to determine the probability that the number of occurrences of E will be included between the limits $m\pm l$.

Let x be any number between 0 and l. Then (92) the probability that E will occur $(m-x)$ times and fail $(n+x)$ times is $P_x=P_o e^{-hx^2\div 2mn}$ (where $P_o=\sqrt{(h\div 2\pi mn)}$. Now if in this expression we make x successively equal to each of the numbers $0, 1, 2, \ldots l$, we shall have the respective probabilities of E happening m, $m-1$, $m-2, \ldots\ldots m-l$ times in h trials; and the sum of these probabilities will be the probability that E happens *not oftener* than m times, and *not seldomer* than $m-l$ times. The same suppositions with respect to x will

Probability. give the probabilities of E happening $m, m+1, m+2, \ldots m+l$ times, the sum of which will be the probability that E happens *not seldomer* than m times, and *not oftener* than $m+l$ times. Adding, therefore, those two sums, and deducting P_o the probility which corresponds to $x=0$, on account of its being included in each sum, and therefore having been counted twice, the result will be the sum of the terms of the binomial $(p+q)^h$ comprised between, and including, the two terms of which the first has for a factor p^{m+l}, and the last p^{m-l}, and will therefore express the probability that the number of occurrences of E will fall within the limits $m \pm l$. Let this probability be denoted by R, and let SP_x represent the sum of all the values of P_x obtained by substituting successively 0, 1, 2, 3,...l for x, we then have $R=2SP_x-P_o$, whence, writing for P_x and P_o, their values,

$$R=2S\sqrt{\left(\frac{h}{2\pi mn}\right)}e^{-\frac{hx^2}{2mn}}-\sqrt{\frac{h}{2\pi mn}}.$$

95. In order to find an approximate value of this expression we must have recourse to a formula first given by Euler for converting sums of the kind denoted by S into definite integrals (for which see Lacroix, *Traité du Calcul Différentiel et Intégral*, tom. iii. p. 136, or Herschel's *Treatise on Differences*, p. 513). Assuming u to denote a function of x, the formula is as follows:

$$Su=\int u dx+\frac{1}{2}u+\frac{1}{1.2.6}\frac{du}{dx}+\&c.+\text{constant}.$$

On making $u=P_x=P_o e^{-hx^2\div 2mn}$, we find $\frac{du}{dx}=-\frac{P_o hx}{mn}e^{-hx^2\div 2mn}$; therefore, if we suppose x to be not greater than $\sqrt{m}$ or $\sqrt{n}$, this differential coefficient is of the order $1\div h$, (as may be easily shewn by substituting hp for m, and hq for n), and may be rejected, since h is supposed to be a very large number. The above equation therefore becomes

$$SP_x=P_o\int e^{-hx^2\div 2mn}dx+\tfrac{1}{2}P_o e^{-hx^2\div 2mn}+\text{constant};$$

and on supposing $x=0$ this gives $0=-\frac{1}{2}P_o+$ constant, therefore the constant is equal to $\frac{1}{2}P_o$, and we have

$$SP_x=P_o\int e^{-hx^2\div 2mn}dx+\tfrac{1}{2}P_o e^{-hx^2\div 2mn}+\tfrac{1}{2}P_o.$$

Assume $t=x\sqrt{(h\div 2mn)}$, whence $dt=dx\sqrt{(h\div 2mn)}$; substitute these in the above equation, and it becomes by reason of $P_o=\sqrt{(h\div 2\pi mn)}$,

$$SP_x=\frac{1}{\sqrt{\pi}}\int e^{-t^2}dt+\tfrac{1}{2}P_o e^{-t^2}+\tfrac{1}{2}P_o,$$

whence, from the equation $R=2SP_x-P_o$, we obtain

$$R=\frac{2}{\sqrt{\pi}}\int e^{-t^2}dt+P_o e^{-t^2}.$$

The integral in this expression must be taken between the limits $x=0$ and $x=l$. When $x=0$ we have also $t=0$, and when $x=l$, then $t=l\sqrt{(h\div 2mn)}$; therefore assuming τ for the limiting value of t, that is, making $\tau=l\sqrt{(h\div 2mn)}$, and therefore $l=\tau\sqrt{(2mn\div h)}$, there results

$$R=\frac{2}{\sqrt{\pi}}\int_o^\tau e^{-t^2}dt+P_o e^{-\tau^2}$$

for the probability that the number of occurrences of E will fall between $m\pm\tau\sqrt{(2mn\div h)}$; or, replacing m and n by hp and hq, the probability that the number of occurrences of E will fall within the limits $hp\pm\tau\sqrt{(2hpq)}$, or be equal to one of those limits.

This expression for R has been found by neglecting quantities of the order of smallness $1\div h$; consequently the greater the value of h the more nearly it approaches to accuracy, but it is only rigorously true when h is infinite. Probability.

96. The integral $\int e^{-t^2}dt$ is computed as follows. Developing the exponential e^{-t^2} in a series of the ascending powers of t^2, and integrating the successive terms between the limits $t=0$ and $t=\tau$, we find

$$\int_o^\tau e^{-t^2}dt=\tau-\frac{\tau^3}{1.3}+\frac{\tau^5}{1.2.5}+\frac{\tau^7}{1.2.3.7}+\&c.;$$

a series which converges rapidly when τ is less than unity. In the contrary case, however, or when τ is greater than unity, the series is divergent, and it is necessary to proceed by a different method. Let the factor e^{-t^2} be multiplied and divided by t; we have then

$$\int e^{-t^2}dt=\int\frac{1}{t}e^{-t^2}tdt,$$

and on integrating by parts

$$\int\frac{1}{t}e^{-t^2}tdt=-\frac{e^{-t^2}}{2t}-\tfrac{1}{2}\int\frac{1}{t^2}e^{-t^2}dt.$$

Repeating the same process on the last integral, and so on with the last after each succeeding integration, the following series is obtained,

$$\int e^{-t^2}dt=-\frac{e^{-t^2}}{2t}\left\{1-\frac{1}{2t^2}+\frac{3}{2^2t^4}-\frac{3.5}{2^3t^6}+\&c\right\}.$$

When $t=$ infinity the right hand side of this equation becomes 0; whence between the limits $t=\tau$ and $t=$ infinity, we have

$$\int_\tau^\infty e^{-t^2}dt=-\frac{e^{-\tau^2}}{2\tau}\left\{1-\frac{1}{2\tau^2}+\frac{3}{2^2\tau^4}-\frac{3.5}{2^3\tau^6}+\&c\right\},$$

a series which converges very rapidly when τ is greater than unity. Now the value of a definite integral between 0 and infinity is obviously equal to its two parts, of which the first is taken between 0 and τ, and the second between τ and infinity; that is to say,

$$\int_o^\tau e^{-t^2}dt=\int_o^\infty e^{-t^2}dt-\int_\tau^\infty e^{-t^2}dt.$$

But $\int_o^\infty e^{-t^2}dt$ is well known[1] to have for its expression $\frac{1}{2}\sqrt{\pi}$, therefore

$$\int_o^\tau e^{-t^2}dt=\tfrac{1}{2}\sqrt{\pi}-\int_\tau^\infty e^{-t^2}dt,$$

so that the integral may be computed from either of the above series, according as τ is less or greater than 1.

The integral $\int e^{-t^2}dt$ is of great importance in the higher mathematics. It occurs in the investigation of the path of a ray of light through the atmosphere, and of the law of the diffusion of heat in the interior of solid bodies, as well as in the determination of the degree of reliance that may be placed on the results of astronomical observations, and generally in most of the more difficult and important applications of the theory of probabilities. A table of its values from $t=0$ to $t=3$, for intervals each $=.01$, was given by Kramp, at the end of his *Analyse des Refractions Astronomiques*, Strasburg, 1799. In the *Berliner Astronomisches Jahrbuch* for 1834, there is also a table of its values from $t=0$ to $t=2$ (for the same intervals) multiplied by $2\div\sqrt{\pi}$, with their first and second differences for the purpose of facilitating interpolation. This last table, which appears to have been derived from that of Kramp, and which is immediately applicable in the calculation of the probability R, we have extended to $t=3$, and given at the end of the present article. As the function which is thus tabulated will

[1] The formula $\int_o^\infty e^{-t^2}dt=\frac{1}{2}\sqrt{\pi}$ is ascribed by Gauss (*Theoria Motus Corporum Cœlestium*, p. 212,) to Laplace. On making $e^{-t^2}=z$, the integral is transformed into $\frac{1}{2}\int^\cdot dz\left(\log\frac{1}{z}\right)^{-\frac{1}{2}}$ between the limits $z=0$ and $z=1$, the value of which $=\frac{1}{2}\sqrt{\pi}$, had been given by Euler, long before, in the *Petersburg Memoirs*. See Legendre, *Exercises du Calcul Intégral*, tom. i. p. 301.

Probability. occur frequently in what follows, we shall in future, for convenience in printing, denote it by Θ, that is to say, we shall assume

$$\Theta=\frac{2}{\sqrt{\pi}}\int_0^{\tau}e^{-t^2}dt=1-\frac{2}{\sqrt{\pi}}\int_{\tau}^{\infty}e^{-t^2}dt,$$

the two forms being equivalent in consequence of the above equation.

97. Some very important conclusions follow immediately from the formula in (95). The quantity R denotes the probability that in a very great number of trials h, the event E, of which the *a priori* probability in any trial is p, will occur not seldomer than $hp-l$ times, and not oftener than $hp+l$ times, or that the number of its occurrences will be included between the limits $hp\pm l$, or at least be equal to one of those limits. Hence R also denotes the probability that the ratio of the occurrences of E to the whole number of trials, will be included within the limits $p\pm l\div h$. We have assumed $\tau=l\sqrt{(h\div 2mn)}$; but $m=hp$ and $n=hq$; therefore $\tau=l\div\sqrt{(2hpq)}$, whence $l=\tau\sqrt{(2hpq)}$, and consequently $l\div h=\tau\sqrt{(2pq\div h)}$. Now, if we suppose τ to be constant, so that the probability expressed by R may remain the same, then p and q being given, l is proportional to the square root of h, and consequently the greater the number of trials the smaller will l be in proportion to that number. Thus, if the number of trials be 1000, and we have a given probability R that the number of occurrences of E will not differ more than 10 from the number which is the most probable of all (that is, from $1000\,p$), then if we take 100,000 trials, we shall have the same probability R that the number of occurrences of E will not differ more than $10\times\sqrt{100}=100$ from the most probable number. But a difference of 10 in 1000 is 1-100th of the whole, whilst a difference of 100 in 100,000 is 1-1000th of the whole, and thus the ratio of l to h becomes smaller and smaller, or the ratio of the occurrences of E to the whole number of trials approaches nearer and nearer to p, as the number of trials is increased; and the experiments may be repeated until the difference between p and $p\pm l\div h$, in respect of a given probability R which may be as great as we please, shall be less than any assignable quantity.

If, on the other hand, we suppose $l\div h$ to be constant, then τ is proportional to the square root of the number of trials. But as τ increases, Θ, and consequently R, approaches nearer and nearer to unity, (and it may be seen, by referring to the table, that it is only necessary to have $\tau=3$ in order to have $\Theta=\cdot 9999779$); whence the number of trials h may always be increased until we obtain a probability approaching as nearly to certainty as we please, that the number of occurrences of E will be comprised within the given limits $(hp\pm l)$; or, which is the same thing, that the ratio of the number of occurrences of E to the whole number of trials, shall not differ from p, the probability of E in a single trial, more than a given quantity $l\div h$ which may be less than any assigned fraction. This is the celebrated theorem which was demonstrated by James Bernoulli in the *Ars Conjectandi*.

98. The application of the preceding results to numerical examples, is rendered extremely easy by means of the table of the values of Θ. From the formula in (95) we have the probability

$$R=\Theta+P_x e^{-\tau^2},$$

that the occurrences of E in h trials will fall within the limits $hp\pm l$, the relation between l and τ being given by the equation $l=\tau\sqrt{(2hpq)}$. If, therefore, we suppose l to be given, τ becomes known, and the corresponding value of Θ is found from the table; and, conversely, if Θ be assumed, τ is given by the table, whence the corresponding limits l are deduced. With respect to the quantity $P_x e^{-\tau^2}$, we may observe that it denotes the probability that the number of occurrences of the event E will be $hp+l$ or $hp-l$ precisely (92), and is therefore always a very small fraction when h is a large number (90). It may be regarded as a correction of Θ, which in most cases might be omitted without sensibly affecting the result; but when h is not very large, or l is a small number, it becomes necessary to take it into account. In such cases its value may be computed directly as in the example in (92): but this labour may be avoided by increasing τ, so as to include it within the limits of the integral Θ. Thus, let R be the probability that the number of arrivals of E will be included within the limits $hp\pm x$, and R′ the probability of the limits being $hp\pm(x+1)$, and let Θ and Θ' be respectively the corresponding values of the integral. We have then, giving P_x the same signification as in (92), the two equations

$$R=\Theta+P_x,\quad R'=\Theta'+P_{x+1},$$

and the difference R′—R of these two probabilities is obviously the double of the probability that the result of the trials will be either $(hp+x+1)$ times E, or $(hp-x-1)$ times E, exactly. But the chance of either of these events being P_{x+1}, we have therefore $R'-R=2P_{x+1}$. Now, when h is large, P_x and P_{x+1} are very small, and very nearly equal to each other, (their difference is in fact of the order of quantities omitted); hence $R'-R=\Theta'-\Theta$, and also $2P_{x+1}=2P_x$, and consequently $\Theta'-\Theta=2P_x$, or $P_x=\frac{1}{2}(\Theta'-\Theta)$. Substituting this value of P_x in the equation $R=\Theta+P_x$, we get $R=\frac{1}{2}(\Theta'+\Theta)$; so that if we take from the table the values of Θ' and Θ corresponding to l and $l+1$, half their sum will give R. But as the interval between Θ' and Θ in the table is always small, half their sum will not differ sensibly from the value of Θ corresponding to $l+\frac{1}{2}$, whence this value of Θ is equal to R, and we have the following rule for determining the limits corresponding to a given probability, or *vice versa*:—

When the limits are assumed, find τ from the equation $l+\frac{1}{2}=\tau\sqrt{(2hpq)}$; then the value of Θ in the table, corresponding to τ is the probability that in h trials the number of occurrences of the event E, the chance of which in a single trial is p, will lie within the limits $hp\pm l$ both inclusive. Conversely, when Θ is assumed, find the corresponding value of τ in the table, by means of which the limit l will be given by the equation $l+\frac{1}{2}=\tau\sqrt{(2hpq)}$. It is obvious, that if the limit l and the probability Θ be both assumed, then h may be determined from the same equation.

99. We will now give some examples of the application of the preceding formulæ.

Suppose $p=q=\frac{1}{2}$, and $h=200$, and let it be proposed to assign the limits within which there is a probability $=\frac{1}{2}$ that the number of occurrences of E will fall. In this case the equation $l+\frac{1}{2}=\tau\sqrt{(2hpq)}$ becomes $l+\frac{1}{2}=\tau\sqrt{100}=10\tau$. Now, it is easily found from the table that for $\Theta=\frac{1}{2}$ we have $\tau=\cdot 4769$, whence $l+\frac{1}{2}=4\cdot 769$, and $l=4\cdot 269$. On tossing a shilling 200 times, it is therefore more than an even wager that head will turn up not seldomer than 95 times, and not oftener than 105 times.

Suppose $p=q=\frac{1}{2}$, $h=3600$, and let it be proposed to assign the probability that the number of occurrences of E will not exceed the limits 1800 ± 30. In this case the equation $l+\frac{1}{2}=\tau\sqrt{(2hpq)}$ becomes $30\cdot 5=\tau\sqrt{(2\times 900)}=30\tau\sqrt{2}$, whence $\tau=30\cdot 5\div 30\sqrt{2}=\cdot 7189$; and the table gives $\Theta=\cdot 6907=\frac{29}{42}$ nearly. Hence in tossing a shilling 3600 times, the odds are 28 to 13 that head will not turn up oftener than $1800+30=1830$ times, nor seldomer than $1800-30=1770$ times. Neglecting the second term of R (95) and taking simply $l=10\tau$, the table gives $\Theta=\cdot 6827$, which is the solution given by Demoivre, p. 245.

Suppose $p=\frac{1}{6}$, $q=\frac{5}{6}$, and let it be proposed to determine how many trials must be made in order that it may be one to one that the number of occurrences of E will not differ more than 10 from the most probable number.

Probability. For $\Theta=\frac{1}{2}$ we have $\tau=\cdot4769$; therefore the equation $l+\frac{1}{2}=\tau\sqrt{(2hpq)}$ becomes $10\cdot5=\cdot4769\sqrt{(10h\div36)}$, whence $h=3\cdot6(10\cdot5\div\cdot4769)^2$. On computing this formula h is found $=1745\cdot2$. Say 1746, $\frac{1}{6}$ of which is 291; and it follows that if a die be thrown 1746 times it is an even wager that the number of aces will fall between 291 ∓ 10, that is, between 281 and 301, or be equal to one of those numbers.

In (92) we found the probability to be ·0053, that in 6000 throws of a die the number of aces will be exactly 960. Let it now be proposed to assign the probability Θ, that in 6000 throws the number of aces will lie between 960 and 1040, that is, between 1000 ∓ 40. Here $h=6000$, $p=\frac{1}{6}$, $q=\frac{5}{6}$, and $l=40$; the equation of the limits therefore becomes $40\cdot5=\tau\sqrt{(10000\div6)}$, whence $\tau=\cdot405\sqrt{6}=\cdot992$, corresponding to which the table gives $\Theta=\cdot8394$.

The following question is discussed by Nicolas Bernoulli in the Appendix to Montmort's *Analyse des Jeux de Hazard*, and is noticed by Demoivre and Laplace. From the observations of the births of both sexes in London during 82 years (from 1629 to 1711) it was found that the average number of children annually born in London, was about 14,000, and the ratio of the number of males to that of females, was nearly as 18 to 17, the average number of male births being 7200, and of female births 6800. In the year in which the greatest difference from this ratio took place, the actual numbers were 7037 males and 6963 females, so that the difference from the average amounted to 163. Assuming, then, the comparative facility of male and female births to be as 18 to 17, required the probability that out of 14000 children born, the number of males shall not be greater than 7363, nor less than 7037.

This question is evidently equivalent to the following:— Let 14000 dice, each having 35 faces, 18 white and 17 black, be thrown; what is the probability that the number of white faces turned up, will be comprised between the limits 7200 ∓ 163. We have therefore $h=1400$, $p=\frac{18}{35}$, $q=\frac{17}{35}$, $l=163$, and the formula $l+\frac{1}{2}=\tau\sqrt{(2hpq)}$ becomes $163.5=\tau\sqrt{(2\times14000\times18\times17)}\div35$, whence $\tau=1\cdot955$. The corresponding value of Θ is found from the table $=\cdot9943$, which is the probability that the number of white faces shall not be greater than 7363, nor less than 7037. The odds in favour of the event are therefore 9943 to 57, or about 175 to 1.

100. We now proceed to consider the case in which the probabilities of the simple events are not known, *a priori*, but inferred from the results of experience. It was shewn in (52) that the probability Π of an event happening m' times, and failing n' times in h' trials, $(h'=m'+n')$, when it has been observed to happen m times, and fail n times in h previous trials, is expressed by this equation

$$\Pi=\mathrm{U}'\frac{[m+m'][n+n'][h+1]}{[m][n][h+h'+1]}.$$

Now, when m, n, m', n', are large numbers, an approximate value of Π, more accurate in proportion as those numbers become larger, is obtained from Stirling's theorem (90), which for any number x gives $[x]=x^xe^{-x}\sqrt{(2\pi x)}$. Applying the theorem therefore to the expressions within the brackets in the above equation, and assuming

$$\mathrm{K}=\frac{h+1}{h+h'+1}\sqrt{\frac{(m+m')(n+n')(h+1)}{mn(h+h'+1)}},$$

we obtain, in consequence of $m+n=h$,

$$\Pi=\mathrm{U}'\mathrm{K}\frac{(m+m')^{m+m'}(n+n')^{n+n'}(h+1)^h}{m^mn^n(h+h'+1)^{h+h'}}.$$

Let $m'=\theta m$, $n'=\theta n$, and consequently $h'=\theta h$; then taking $\frac{h^h}{(h+h')^{h+h'}}$ for $\frac{(h+1)^h}{(h+h'+1)^{h+h'}}$ (which may be done without sensible error, since h is by supposition a large number,) the equation becomes Probability.

$$\Pi=\mathrm{U}'\mathrm{K}\frac{m(1+\theta)^{m+m'}n(1+\theta)^{n+n'}h^h}{m^mn^n(1+\theta)^{h+h'}};$$

or, since $m+n=h$, $m'+m'=h'$,

$$\Pi=\mathrm{UK}\frac{m^{m'}n^{n'}(1+\theta)^{h+h'}}{h^h(1+\theta)^{h+h'}}=\mathrm{UK}\left(\frac{m}{h}\right)^{m'}\left(\frac{n}{h}\right)^{n'}.$$

Making the same substitutions in the expression denoted by K, we get, after reduction, $\mathrm{K}=1\div\sqrt{(1+\theta)}$; whence,

$$\Pi=\frac{\mathrm{U}'}{\sqrt{1+\theta}}\left(\frac{m}{h}\right)^{m'}\left(\frac{n}{h}\right)^{n'}.$$

The value of Π now found, is the probability that in a future series of trials the ratio of the occurrences of E to those of F will be the same as in the preceding trials, which are supposed to have been very numerous. If the chances of E and F had been given *a priori* equal to $m\div h$ and $n\div h$ respectively, the probability of m' times E, and n' times F in $m'+n'$ future trials would have been $\mathrm{P}=\mathrm{U}'\left(\frac{m}{h}\right)^{m'}\left(\frac{n}{h}\right)^{n'}$ by (12); hence (since $m'\div h'=m\div h$ and $n'\div h'=n\div h$), the relation between the probability P_o of that combination of simple events which has the greatest number of chances in its favour, when the chances of the simple events are known *a priori*, and the probability of the same combination when the chances of the simple events are only presumed from previous trials, is expressed by this equation,

$$\Pi=\mathrm{P}_o\div\sqrt{(1+\theta)}.$$

101. When h' is very small in comparison of h, θ becomes a very small fraction, and may be neglected, and we have then $\Pi=\mathrm{P}_o$. But when h' is a number comparable with h, Π is less than P_o; and it diminishes rapidly when θ exceeds 1. The reason of this is obvious. If the contents of the urn are not known *a priori*, however numerous the trials may have been there is only a presumption that the chance of drawing a white ball in a single trial is measured by $m\div h$; whereas, in the case of the ratio of the balls being previously known, the measure of the probability is certain. As an instance of the manner in which the probability of an assigned series of future events diminishes, when the probabilities of the simple events are inferred from experience, let us suppose $h'=h$, whence $\theta=1$, and consequently $\Pi=\mathrm{P}_o\div\sqrt{2}=\cdot7071\times\mathrm{P}_o$. Now it was shewn in (91) that if a ball be drawn at random 100 times from an urn which contains an equal number of black and white balls, the probability P_o, that the result will be 50 white balls, and 50 black, precisely, is ·07979. It follows therefore, that if the contents of the urn be unknown, and we can only judge of the relative numbers of the two sorts of balls it contains from having observed that in 100 trials there have been drawn 50 white balls and 50 black, the probability Π of that combination in 100 future trials, becomes $\cdot07979\times\cdot7071=\cdot05642$.

102. The result obtained in (100) enables us to determine the probability that the number of occurrences of E in h' future trials, will not differ in excess or defect from the most probable number, by more than a certain given number l. It has been shewn (95) that in the case of the probabilities p and q of the simple events being given *a priori*, if we determine τ from the equation $l=\tau\sqrt{(2hpq)}$, the formula

$$\mathrm{R}=\Theta+\sqrt{(1\div2\pi hpq)}e^{-\tau^2}$$

gives the probability R that m will be comprised within the limits $hp\mp\tau\sqrt{(2hpq)}$; or, dividing by h, the probability that the ratio of m to h will be comprised within the limits

Probability. $p = \pm \tau\sqrt{(2pq \div h)}$. Conversely[1], when p and q are not known, but the event E has been observed to happen m times in h trials, then

$$R = \Theta + \sqrt{(h \div 2\pi mn)}e^{-\tau^2}$$

gives the probability R that p is comprised within the limits

$$\frac{m}{h} \pm \frac{\tau}{h}\sqrt{\frac{2mn}{h}}.$$

These limits approach more nearly to each other as h increases; and when h is a large number, the ratios $m \div h$, $n : h$ may be assumed, without sensible error, as the chances of E and F in computing the probable result of a future series of h' trials, provided, however, that h' (though absolutely a large number) be small relatively to h. When this condition is not fulfilled, the assumption of $m \div h$ and $n \div h$ as the *a priori* chances of E and F, might lead to considerable error; but an approximation to the limits corresponding to a given value of R may be obtained from the following considerations:—

Suppose a large number h of events to have been observed, and that the result of the observation gave m times E and n times F. Let a new series of h' trials be made, and *suppose* that in this new series p is the real chance of E and q of F; we have then a given probability R that the number of occurrences of E will fall within the limits $h'p \pm \tau\sqrt{(2h'pq)}$. Now, for p and q substitute the ratios observed in the first set of experiments, namely, $m \cdot h$ and $n \div h$, and the limits corresponding to R become

$$\frac{mh'}{h} \pm \frac{\tau}{h}\sqrt{(2h'mn)},$$

which, therefore, are the true limits on the hypothesis that the chance of E in a single trial is $m \div h$. But as this chance is not certain, but only presumed, the limits require to be extended in order that R may preserve the same value. Confining our attention to Θ, the first term of the expression for R (the second may be disregarded in the present approximation), let $h' = m' + n'$ and $m' : n' = m : n$, then Θ is the sum of the terms of the binomial $(p+q)^{h'}$ from that in which the exponent of p is $m' + l$ to that in which the exponent is $m' - l$. Now, when p and q are given *a priori*, the chance of m' times E and n' times F in h' trials is P_o; and when p and q are only presumed from the results of previous trials, the chance of the same combination is Π; and (100) Π is less than P_o in the ratio of 1 to $\sqrt{(1+\theta)}$. In like manner, the chance of each of the other combinations of E and F included in the integral Θ will be less in the case of p and q presumed, than in the case of p and q given, in the same ratio of 1 to $\sqrt{(1+\theta)}$. But it has been seen (93) that when h' is a large number, the terms of the developement of $(p+q)^{h'}$ which are nearest the greatest term, diminish at first very slowly; and, further, that only a small number of terms on each side of the greatest are required to be taken, since l is less than $\sqrt{m'}$ or $\sqrt{n'}$ (95); we may therefore, without sensible error, assume Θ to be proportional to the number of terms included in the summation, or that the value of Θ will not be changed if we include in the summation a number of terms greater in proportion as the value of each individual term is less. Hence it follows that the limits must be increased in the ratio of $\sqrt{(1+\theta)}$ to 1, and the value of Θ corresponding to τ will give the probability that the number of events E, in h' future trials, will be included between

$$\frac{mh'}{h} \pm \frac{\tau}{h}\sqrt{(2h'mn(1+\theta))}.$$

Probability.

103. The following question may be proposed as an example of the application of the last formula. Out of a given number h of individuals taken at the age A, it has been observed that m are alive at the age $A+a$; required the probability that out of h' other individuals taken at the same age A the number who survive at the age $A+a$ will be included between $m' \pm l$, the ratio of m' to h' being the same as that of m to h.

To solve this question, we have to find τ from the equation $l = \frac{\tau}{h}\sqrt{(2h'mn(1+\theta))}$; and the corresponding value of Θ in the table, will give the required probability.

From the table given in the article MORTALITY, vol. XV. p. 555, it appears that out of 5642 individuals taken at the age 30, the number surviving at the age 50, according to the Carlisle Table, is 4397. Taking those numbers as an example, we have $h = 5642$, $m = 4397$, $n = 1245$; and assuming also $h' = 5642$, whence $\theta = 1$ and $\sqrt{(1+\theta)} = \sqrt{2}$, the equation of the limits becomes $l = \tau \times 62{\cdot}30$, Let it be proposed to determine l from the condition $\Theta = \frac{1}{2}$. In this case the table gives $\tau = {\cdot}4769$, and we have consequently $l = 29{\cdot}7$. Hence it appears, that if it has been observed that of 5642 individuals taken at the age of 30, 1245 die before reaching the age of 50, it is an even wager that out of 5642 other individuals also taken at the age of 30, and subjected to the same chances of mortality, the number who die before reaching the age of 50 will lie between 1245 ± 30, that is, between 1215 and 1275.

104. The following experiment recorded by Buffon, in his *Arithmetique Morale*, affords an example of the application of the preceding formulæ to the determination of the probable existence of a physical cause from the results of a large number of observations. A piece of money was tossed 4040 times successively, and the result was head 2048 times, and tail 1992 times. Supposing the piece to have been perfectly symmetrical, the most probable result would have been the same number of heads and tails. Let it now be proposed to assign the probability afforded by the experiment that the piece was not symmetrical, and that its form or physical structure was such as to render head an event, *a priori*, more probable than tail.

In this case $h = 4040$, $m = 2048$, $n = 1992$; and by (102) we have the probability R (or Θ, neglecting the correction) that p, the unknown chance of head, is comprised between the limits $\frac{m}{h} \pm \frac{\tau}{h}\sqrt{\frac{2mn}{h}}$. Now $\frac{m}{h} = \frac{2048}{4040} = .50693$, and $\frac{\tau}{h}\sqrt{\frac{2mn}{h}} = \tau \times .011124$, therefore if we assume $\tau \times .011124 = .00693$, we shall have the probability Θ that p is comprised between the limits $.50693 \pm .00693$, that is, between two limits of which the least is .5, or one-half. This assumption gives $\tau = .00693 \div .011124 = .623$; and the corresponding value of Θ is found from the table $= .62170$. Now if p lie between the above limits, its value is evidently greater than $\frac{1}{2}$; but the probability of its lying between those limits is not the whole probability that p is greater than $\frac{1}{2}$; for there is a chance of its exceeding the greatest limit, in which case also its value will be greater

[1] This inference, though admitted by both Laplace and Poisson, is not strictly correct. In a paper published in the *Transactions of the Cambridge Philosophical Society*, (vol. vi. part iii.) Mr. De Morgan has shewn by a direct analysis that in the case of p and q not being known *a priori*, but made equal to the observed ratios $m \div h$, $n \div h$, the presumption of the true value of p lying within the limits stated in the text is not, as there inferred, $\Theta + \frac{1}{\sqrt{(2\pi hpq)}}e^{-\tau^2}$, but $\Theta - \frac{13p^2 - 13p + 1}{6hpq\sqrt{\pi}}e^{-\tau^2}$. The last correction to Θ is smaller than the former, and being divided by h, is of the order of quantities that have been rejected in the approximations. It is right to state that the method of simplifying the calculation of R in the direct case, by taking the integral Θ between limits corresponding to $l + \frac{1}{2}$ instead of l, is noticed, for the first time so far as we are aware, by Mr. De Morgan in the same paper.

Probability. than $\frac{1}{2}$. The probability that p is *not* comprised between the assumed limits is $1-.62170=.37830$; and if it is not comprised between these limits, there is an equal chance of its being greater than the greatest limit, or less than the least; the probability of its exceeding the greatest limit is consequently $\frac{1}{2}\times.37830=.18915$. Hence the whole probability that p is greater than .5, or that the chance of head is greater than that of tail is $.62170+.18915=.81085$; and the odds are therefore 81 to 19, or rather more than 4 to 1 that the piece was not perfectly symmetrical.

105. The formulæ which have been demonstrated in the present section are immediately applicable to the determination of the probable limits of the gain or loss which may arise from undertaking a great number of risks with a given expectation in respect of each. The following question has important practical applications. A is interested in a great number of similar enterprises, in each of which E or F must necessarily happen. When E happens he receives the sum α, and when F happens he pays the sum β; required the probability that his gain or loss shall be comprised within given limits?

Let p be the chance of the event E, q that of F, and h the number of enterprises. Suppose E happens m times, and F n times; the sum to be received will be $m\alpha$, and the sum to be paid will be $n\beta$, and therefore his gain will be $m\alpha-n\beta$. Let $m=hp$, $n=hq$, then m times E and n times F is the most probable result, and in this case the gain $m\alpha-n\beta$ becomes $h(v\alpha-q\beta)$. Find τ from $l+\frac{1}{2}=\tau\sqrt{(2hpq)}$, then (98) Θ is the probability that the number of occurrences of E will lie between the limits $hp\mp l$. But if E happens $hp-l$ times, and consequently F $hq+l$ times, the corresponding benefit is $(hp-l)\alpha-(hq+l)\beta=h(p\alpha-q\beta)-l(\alpha+\beta)$; and if E happens $hp+l$ times, and F $hq-l$ times, the benefit is $(hp+l)\alpha-(hq-l)\beta=h(p\alpha-q\beta)+l(\alpha+\beta)$; whence Θ is the probability that his gain, that is, the difference between what he receives and what he pays, will be included within the limits $h(p\alpha-q\beta)\mp l(\alpha+\beta)$ both inclusive.

106. The following conclusions follow immediately from this solution.

(1). If $p\alpha$ be greater than $q\beta$, so that A has a mathematical advantage (however small) in each risk, the risk may be repeated a sufficient number of times, or h may be taken a sufficiently high number, to give a probability as nearly equal to certainty as we please, that A's gain shall exceed any given sum, however great.

(2). Let there be two players A and B, whose chances of gaining a game are respectively p and q, and let β be the sum staked upon each game by A, and α the sum staked by B, then $p\alpha$ is the mathematical expectation of A in respect of a single game, and $q\beta$ that of B; and if $p\alpha$ be greater than $q\beta$ (however small the difference) the game may be repeated so often as to give rise to a probability approaching as nearly to certainty as we please, that A's gain shall become equal to the whole of B's capital, and, consequently, that B will be ruined.

(3). If the mathematical expectations of the two players be equal, then $p\alpha-q\beta=0$, and the most probable individual result of a large number of games, is that the gains and losses on either side shall be the same. But if l be supposed constant, then τ is inversely proportional to $\sqrt{h}$, and consequently the game may be repeated until Θ, the probability that the gain or loss $l(\alpha+\beta)$ shall be comprised within given limits, shall become as small as we please. Hence $1-\Theta$, the probability that the gain or loss shall *not* be comprised within given limits, may be rendered as great as we please; and it follows that although the play may be on terms of perfect equality, it may be continued until a probability shall be obtained, approaching as nearly to certainty as we please, that one of the two players shall be ruined.

(4). The number of games which must be played, to afford a given amount of probability that one of the parties shall lose the whole of his fortune, depends on the magnitude of the stakes $(\alpha+\beta)$; but whether the stakes be large or small, the final result is the same. When the stakes are small, a greater number of games must be played. Probability.

107. As an example of this class of problems, we may take the following question: A and B engage in play with equal chances of winning, and stake five sovereigns on each game; how many games must they undertake to play in order that it may be two to one that one of them shall lose *at least* 100 sovereigns?

Here $p=\frac{1}{2}$, $q=\frac{1}{2}$, $\alpha=5$, $\beta=5$, and $l(\alpha+\beta)=100$, whence $l=10$. The equation $l+\frac{1}{2}=\tau\sqrt{(2hpq)}$ therefore becomes $10{\cdot}5=\tau\sqrt{(h\div2)}$, whence $h=2\times(10{\cdot}5)^2\div\tau^2$. Now, the odds being 2 to 1 against the limits of the gain or loss not exceeding 100, the probability Θ of the limits not exceeding 100 is $\frac{1}{3}=\cdot33333$, corresponding to which the table gives by interpolation $\tau=\cdot30458$; substituting which in the above equation we find $h=2376{\cdot}8$; so that if 2377 games are played, the odds are 2 to 1 that one of the players shall have gained at least 10 games more than half that number, and, consequently, that the other shall have gained at least 10 less than half, or that one of them shall have gained at least 20 games more than the other, and consequently have gained at least 100 sovereigns.

It is to be carefully observed that this question supposes the account between A and B not to be balanced until 2377 games have been played. If the condition of the play had been that it should cease as soon as A or B should have lost 100 sovereigns, the question would have been of an entirely different kind, and a much smaller number of games would have given the same probability of an equal loss.

108. The question just alluded to belongs to a class of problems connected with the *Duration of Play*, of extreme difficulty, and which have given rise to some of the most abstruse and refined researches in the modern analysis. In order to give an idea of the subject, we may take the following question, which has been frequently considered.

A and B, whose chances of winning a game are respectively p and q, play on these terms: A has m counters, and B has n counters; when A loses a game he gives a counter to B, and when B loses a game he gives a counter to A, and the play is to cease when one of them has lost all his counters. What is the probability that the play, which may go on for ever, shall be finished before more than h games shall have been played.

To take a simple case, suppose each to have three counters, and let the probability be required that the play shall be concluded with or before the ninth game. As the play cannot end with less than three games, let the binomial $(p+q)^3$ be developed, and the terms

$$p^3+3p^2q+3pq^2+q^3$$

give the respective probabilities of all the cases which can arise in three games. The first term is the probability of A gaining all the three games, the last term is the probability of B gaining them, and the sum of the remaining two terms is the probability that neither will win all the games, or the chance that a fourth will be played. Now, if the fourth game be played, p is A's chance of winning it, and q B's chance; but these chances will only exist in respect of the fourth game, provided the play be not concluded with the previous one, the probability of which is $3p^2q+3pq^2$. Multiplying, therefore, $3p^2q+3pq^2$ by $p+q$, the product

$$3p^3q+6p^2q^2+3pq^3$$

gives the respective probabilities of the different ways in which the four games may be gained by A and B, excepting the two ways in which the play would have terminated with the third game. But the play cannot end in any of these ways; for, taking the first term for example, if B gains a counter before A gains three, the play cannot terminate until A gain back that counter, and three others besides, so that five games must be played. In fact, it is

Probability. obvious that there is no way of gaining an odd number of counters in an even number of games, or *vice versa*. The last product therefore expresses the chance of the 5th game being played; and by reason of $p+q=1$ it is equal to $3p^2q+3pq^2$, the chance of the 4th being played, as it obviously ought to be, since the play cannot terminate with the 4th. Again, if the 5th game be played, p is A's chance of gaining it, and q B's chance of gaining it; multiplying therefore the last product by $p+q$, the different terms of the result, namely,

$$3p^4q+9p^3q^2+9p^2q^3+3pq^4$$

give the respective probabilities of all the cases which can arise by the 5th game. The first term is the probability of A gaining 4 games and B gaining 1, and the last term is the probability of B gaining 4 and A gaining 1. These terms therefore are the probabilities of the play ending in favour of A and B respectively with the 5th game, and the sum of the other two terms is the probability that the play will not terminate with the 5th game, or the chance of another game being played.

By pursuing the same reasoning it will be evident that on rejecting the two extreme terms of the above product, and multiplying the remainder by $p+q$, there will result the probabilities of the different ways in which six games may be played without the one player gaining all the counters of the other. But as the play cannot termimate with the 6th game, multiply again by $p+q$, and the result

$$9p^5q^2+27p^4q^3+27p^3q^4+9p^2q^5$$

will indicate the probability of the different cases that can arise out of the 7th game. Rejecting the two extreme terms, which give the respective probabilities of the play being concluded in favour of A or B, and multiplying the remaining two first by $p+q$ to obtain the different probabilities in respect of the 8th game, and again by $p+q$, as the play cannot terminate with the 8th, we have the product

$$27\,p^6q^3+81\,p^5q^4+81\,p^4q^5+27\,p^3q^6,$$

of which the first and last terms give the respective chances of A and B winning at the 9th game, and the sum of the other two terms the probability that the play will not be concluded by the 9th.

If we now collect the terms which have been set aside in the successive products, and denote by a and b the respective probabilities of A and B gaining at the 9th game, *or sooner*, we shall have

$$a=p^3+3p^4q+9p^5q^2+27p^6q^3,$$
$$b=q^3+3q^4p+9q^5p^2+27q^6p^3,$$

where the law of the series is evident.

It is easy to see that this process may be applied whatever be the number of counters which A and B have at the commencement, and whatever be the number, h, of games to which the play is limited. The general rule is as follows: of the two numbers m and n, let m be that which is not less than the other. Raise $p+q$ to the power n, and reject the first term (which gives the chance of A winning n games in succession), and also the last if $m=n$. Multiply the remainder $(h-n)$ times in succession by $(p+q)$, rejecting at each multiplication the first or last term of the product when it gives a combination which would terminate the play in favour of A or B; the sum of the terms rejected from the left-hand side of the different products gives the probability in favour of A, and the sum of the terms rejected from the right-hand side the probability in favour of B. As the coefficients of the successive products are obviously formed by adding the coefficient of the corresponding term in the preceding product to that of the term immediately before it, the products may be written down at once without the trouble of multiplication; but it is evident that when m, n, and h are large numbers, it would be quite impracticable to sum the series formed of the rejected terms by the ordinary methods. From the manner in which the series are derived, they are called *recurring* series; a general theory of which was first given by Demoivre in his *Doctrine of Chances*, and forms the most remarkable portion of that work.

109. The general problem is reduced to an equation of finite differences as follows: Let $y_{x,t}$ represent A's expectation when x games have been played, and he has still t counters to win, or B has t counters in his hand. If A gain the next game the value of his expectation will become $y_{x+1,t-1}$, and the chance of his gaining it is p; therefore his expectation in respect of that event is $py_{x+1,t-1}$. On the other hand, if A loses the next game his expectation will become $y_{x+1,t+1}$, and the chance of losing it is q; therefore his expectation in respect of that event is $qy_{x+1,t+1}$. Hence, according to the principles laid down in (32),

$$y_{x,t}=py_{x+1,t-1}+qy_{x+1,t+1}$$

a linear equation of finite differences, with three independent variables. It is therefore on the integration of an equation of this kind that the problem of the duration of play ultimately depends, but the subject is of much too complicated a nature to admit of its being satisfactorily explained in this place. We must therefore content ourselves with referring the reader to the treatise on generating functions, which forms the first part of the *Théorie Analytique* of Laplace.[1]

SECT. IX. OF THE MOST PROBABLE MEAN RESULTS OF NUMEROUS DISCORDANT OBSERVATIONS, AND THE LIMITS OF PROBABLE ERROR.

110. In the preceding section we have considered a class of questions which apply to events depending on constant causes, and supposed to be of such a nature that they necessarily happen or fail in each experiment, and have given formulæ by which approximate results can be obtained when the numbers involved are so large that they cannot be conveniently treated, or cannot be treated at all, by the ordinary methods of calculation. We come now to a more difficult problem, namely, to investigate the probable result of a large number of observations which have reference not to the simple occurrence or failure of a certain event, but to the magnitude of a thing, susceptible, within certain limits, of a very great or an infinite number of different values, equally or unequally probable, the chance of any particular value being also supposed to vary in each experiment. On account of its immediate application to the determination of the most probable values of astronomical and physical elements from the results of observation, this is, perhaps, in reference to practical utility, the most important question in the theory.

111. Let A represent a thing of any sort (as a line, or an angle, or a function of any quantity) which may have

[1] Lagrange, in vol. i. of the *Memoirs of the Society of Turin*, was the first who shewed that the investigation of the general term of a recurring series depends on the integration of a linear equation of finite differences. In vols. vi. and vii of the *Memoires présentés à l'Academie des Sciences* of Paris, Laplace proposed a general method for the summation of recurring series by the integration of such equations, and in the latter volume gives a number of examples of their use in the more complicated questions in the theory of chances, amongst which is the problem enunciated in (108). The subject was afterwards resumed by Lagrange in the volume of the *Berlin Memoirs* for 1775, where he has given a more direct method than that of Laplace, for the integration of the class of equations in question, and also applied it to the solution of the principal problems proposed in the works of Montmort and Demoivre. A general solution of the problem in the text is given by Ampère in a Tract entitled *Considérations sur la Théorie Mathématique du Jeu*, (Lyons, 1802.)

Probability. every possible value within given limits, or which may be constant in itself, but of such a nature that its real magnitude can only be observed within certain limits of accuracy, and suppose a great number of observations to be made. The object is, in the first place, to assign the probability that the sum of the observed values shall fall within given limits, supposing the chances of the different values of A to be known *a priori*; and, in the second place, when the law of the chances is unknown, to determine from the observations themselves the most probable mean value of A, and also the limits within which there is a given amount of probability that the difference between such mean value, and the true but unknown value of A. shall be contained.

112. Let a and b be the limits of the possible values of A, x a value of A between a and b, and P the probability that the sum of the values of A given by h observations will be s exactly, s being a given quantity between ha and hb. Assume the values of A to be equidifferent, and multiples of a certain constant ϵ, and make

$$a\epsilon=a,\ \beta\epsilon=b,\ \sigma\epsilon=s,\ i\epsilon=x,$$

where a, β, and σ are whole numbers (which may be positive or negative), and i is also a whole number proportional to x, and varying between the limits $i=a$, and $i=\beta$, and which, therefore, may be positive or negative, or zero. If the different values of A are supposed to be equally probable, the chance of obtaining any given one of them, as x, in a single trial is unit divided by the number of possible values, or equal to $1\div(\beta-a+1)$; and if we assume an indeterminate quantity w, then (20) the number of combinations which give the sum of h values of A equal to $\sigma\epsilon$ is the coefficient of that term of the multinomial

$$(w^{\alpha}+w^{\alpha+1}+w^{\alpha+2}\ldots\ldots+w^{\beta})^{h},$$

(or of the developement of $(\Sigma w^{i})^{h}$ from $i=a$ to $i=\beta$) in which the exponent of w is σ; and consequently the probability P that the sum of the values of A will be s exactly is that coefficient divided by $(\beta-a+1)^{h}$.

113. If the chances of the different values of A are unequal, and also vary in each trial, let p_1 be the probability of the observed value of A being x in the first trial, p_2 the probability of its being x in the second, p_3 that of its being x in the third, and so on. Now when $h=1$, or when there is only a single trial, then $s=x=i\epsilon$, and we have $P=p^{1}$. If $h=2$, then, assuming $i\epsilon$ to be the value of A in the first trial, and $i'\epsilon$ its value in the second, (i and i' being any two numbers between a and β), the two observations may give the sum of the two values equal to $\sigma\epsilon$ in as many different ways as it is possible to satisfy the equation $i+i'=\sigma$; and consequently, according to the theory of combinations, P is the coefficient of that term of the product (arranged according to the powers of w) of the two series represented by $\Sigma p_1 w^{ii}$ and $\Sigma p_2 w^{ii}$, in which the exponent of w is equal to $\sigma\epsilon$. In like manner, if $h=3$, then the sum of the observed values of A may be equal to $\sigma\epsilon$ in as many different ways as the equation $i+i'+i''=\sigma$ admits of different solutions, and consequently P is the coefficient of the term of the developement of the product $\Sigma p_1 w^{ii}\cdot\Sigma p_2 w^{ii}\cdot\Sigma p_3 w^{ii}$, in which the exponent of w is equal to $\sigma\epsilon$. Generally, when the number of observations is h, the probability P of the sum of the observed values of A being s, or $\sigma\epsilon$, exactly, is the coefficient of $w^{\sigma i}$ in the developement of the product

$$\Sigma p_1 w^{ii}\cdot\Sigma p_2 w^{ii}\cdot\Sigma p_3 w^{ii}\ldots\ldots\ldots\Sigma p_h w^{ii},$$

the sums Σ including all values of i from $i=a$ to $i=\beta$.

Assume $w^{i}=e^{\theta\sqrt{-1}}$ (e being the base of the Napierean logarithms), and let the above product be denoted by X. We shall then have

$$X=\Sigma p_1 e^{i\theta\sqrt{-1}}\cdot\Sigma p_2 e^{i\theta\sqrt{-1}}\cdot\Sigma p_3 e^{i\theta\sqrt{-1}}\ldots\ldots\Sigma p_h e^{i\theta\sqrt{-1}}.$$

Probability. Now since P is the coefficient of the term of the developement of this product which contains the factor $e^{\sigma\theta\sqrt{-1}}$, if we conceive the developement effected we shall have

$$X=Pe^{\sigma\theta\sqrt{-1}}+P'e^{\sigma'\theta\sqrt{-1}}+\&c.$$

a series in which all the terms are of the same form. Multiplying both sides of the equation by $e^{-\sigma\theta\sqrt{-1}}$, we get

$$Xe^{-\sigma\theta\sqrt{-1}}=P+P'e^{(\sigma'-\sigma)\theta\sqrt{-1}}+\&c.$$

Now by a well known theorem in trigonometry, (ALGEBRA, art. 269), $e^{(\sigma'-\sigma)\theta\sqrt{-1}}=\cos(\sigma'-\sigma)\theta+\sqrt{-1}\sin(\sigma'-\sigma)\theta$; substituting therefore this value, and multiplying by $d\theta$, the equation becomes

$$Xe^{-\sigma\theta\sqrt{-1}}d\theta=Pd\theta+P'\left\{\cos(\sigma'-\sigma)\theta+\sqrt{-1}\sin(\sigma'-\sigma)\theta\right\}d\theta+\&c.$$

The factor which multiplies P′ in this equation will evidently become zero when integrated from $\theta=-\pi$ to $\theta=+\pi$, (π being the semicircumference to radius 1), the positive and negative elements of the integral being equal, and consequently destroying each other. The same thing also takes place with respect to the following terms, which are all of the same form. Integrating therefore between those limits, and observing that $\int d\theta=2\pi$, we find

$$P=\frac{1}{2\pi}\int_{-\pi}^{+\pi}Xe^{-\sigma\theta\sqrt{-1}}d\theta.$$

114. This value of P denotes the infinitely small chance that the sum of the values of A in h trials will be s exactly. Let μ and ν be two integer numbers between ha and $h\beta$, and let Q denote the probability that s will be comprised between the two limits $\mu\epsilon$ and $\nu\epsilon$, (these limits being included between ha and hb); then Q will be found by substituting successively μ, $\mu+1$, $\mu+2,\ldots\nu$ for σ in the above value of P, and taking the sum of all the resulting terms. This substitution gives the following series multiplied by X under the sign of integration:

$$e^{-\mu\theta\sqrt{-1}}+e^{-(\mu+1)\theta\sqrt{-1}}+e^{-(\mu+2)\theta\sqrt{-1}}\ldots+e^{-\nu\theta\sqrt{-1}}$$

On multiplying the series now found by $e^{\frac{1}{2}\theta\sqrt{-1}}-e^{-\frac{1}{2}\theta\sqrt{-1}}$ ($=2\sqrt{-1}\sin\frac{1}{2}\theta$), all the terms of the product, excepting the first and the last, destroy each other, and the sum of the terms becomes simply

$$e^{-(\mu-\frac{1}{2})\theta\sqrt{-1}}-e^{(\nu+\frac{1}{2})\theta\sqrt{-1}};$$

therefore on making the substitution, and performing the multiplication now indicated, and dividing by $2\sqrt{-1}\sin\frac{1}{2}\theta$, we obtain for the value of Q the equation $Q=$

$$\frac{1}{4\pi\sqrt{-1}}\int_{-\pi}^{+\pi}X\left\{e^{-(\mu-\frac{1}{2})\theta\sqrt{-1}}-e^{-(\nu+\frac{1}{2})\sqrt{-1}}\right\}\frac{d\theta}{\sin\frac{1}{2}\theta}.$$

115. In order to simplify the expression for Q, let the number of possible values of A within the given limits be conceived to be infinite, in which case the constant ϵ becomes infinitely small, and therefore, since the limits are finite, μ and ν infinitely great. Let the following substitutions also be made:

$$\mu\epsilon=\psi-\delta,\ \nu\epsilon=\psi+\delta,\ \theta=\epsilon z,$$

δ being positive in order that ν may be greater than μ, agreeably to what has already been assumed. On substituting these expressions in the above equation, the limits of the new variable z will be $\pm$ infinity; for ϵ having been supposed infinitely small, z must become infinitely great when $\theta=\pi$. Now since μ and ν are infinitely great, $\mu-\frac{1}{2}$ and $\nu+\frac{1}{2}$ become sensibly μ and ν, whence we have

Probability. $e^{-(\mu-\frac{1}{2})\theta\sqrt{-1}}-e^{-(\nu+\frac{1}{2})\theta\sqrt{-1}}=e^{-\psi z}(e^{\delta z\sqrt{-1}}-e^{-\delta z\sqrt{-1}})$ $=e^{-\psi z}2\sqrt{-1}\sin\delta z$. Again, by reason of $\theta=\epsilon z$, we have $d\theta=\epsilon dz$; and ϵ being infinitely small, θ must be a very small arc, therefore $\frac{1}{2}\theta$ may be taken for $\sin\frac{1}{2}\theta$, whence $d\theta\div\sin\frac{1}{2}\theta=2dz\div z$. By means of these transformations the expression for Q becomes

$$Q=\frac{1}{\pi}\int_{-\infty}^{+\infty} Xe^{-\psi z\sqrt{-1}}\sin\delta z\,.\,\frac{dz}{z},$$

and denotes the probability that the sum of the h values of A will lie between $\psi\mp\delta$.

116. It is now necessary to assign a value to the product denoted by X. Since the number of possible values of A between a and b has been supposed infinite, the chance of obtaining any given one of them, as x, in a single trial, is infinitely small. Assuming this chance to be a function of x, and to vary in the different trials, let it be represented by $\phi_n x$ in respect of the nth trial. In order to preserve continuity in the values of A, this must be understood as signifying that $\phi_n x dx$ is the infinitely small chance that the value of A given by the nth observation will lie between x and $x+dx$. The function $\phi_n x$, therefore, represents the *law of the facility* of the different values of A. It is positive for all values of x between a and b, and vanishes for all values of x less than a or greater than b; and it is important to remark, that whatever number n may be, the integral $\int\phi_n x dx$ taken from $x=a$ to $x=b$ is always equal to unity; for since every observation gives a value of A between a and b, the sum of all the probabilities in respect of each observation must be unity or certainty. From this assumption, then, we have $\phi_1 x dx=p_1$, $\phi_2 x dx=p_2$..... $\phi_h x dx=p_h$, whence the sums $\Sigma p_n e^{i\theta\sqrt{-1}}$ (113) are changed into definite integrals; and therefore, since $\theta=\epsilon z$, $x=i\epsilon$, and consequently $i\theta=xz$, we obtain for the value of X,

$$X=\int e^{zx\sqrt{-1}}\phi_1 x dx\,.\int e^{zx\sqrt{-1}}\phi_2 x dx....\int e^{zx\sqrt{-1}}\phi_h x dx,$$

the limits of the integrals being $x=a$ and $x=b$.

By reason of $e^{zx\sqrt{-1}}=\cos zx+\sqrt{-1}\sin zx$, each of these integrals may be expressed in terms of the cosine and sine of zx. The nth, for instance, becomes $\int\phi_n x\cos zx.dx+\sqrt{-1}\int\phi_n x\sin zx.dx$. Now since $\int\phi_n dx=1$, (from $x=a$ to $x=b$), and $\phi_n x$ can have only positive values, each of the integrals is less than 1; whence we may assume

$$\int\phi_n x\cos zx.dx=R_n\cos r_n;\ \int\phi_n x\sin zx.dx=R_n\sin r_n;$$

R_n being a positive quantity, and r_n an angle having always a real value. This gives

$$\int e^{zx\sqrt{-1}}\phi_n x dx=R_n(\cos r_n-\sqrt{-1}\sin r_n)=R_n e^{r_n\sqrt{-1}};$$

whence substituting successively for n the numbers 1, 2, 3...h, and for the sake of brevity making

$$Y=R_1\times R_2\times R_3.....\times R_h,$$
$$y=r_1+r_2+r_3.....+r_h,$$

we get $X=Ye^{y\sqrt{-1}}$; and the expression for Q becomes

$$Q=\frac{1}{\pi}\int_{-\infty}^{+\infty} Ye^{(y-\psi z)\sqrt{-1}}\sin\delta z\,.\,\frac{dz}{z}.$$

117. The integral in this last expression is equivalent to two others, namely

$$\int Y\cos(y-\psi z)\sin\delta z.\frac{dz}{z}+\sqrt{-1}\int Y\sin(y-\psi z)\sin\delta z.\frac{dz}{z}.$$

Now, on attending to the nature of the quantities represented by Y and y, it will be manifest that according as z is positive or negative, r_n, and consequently y is positive or negative, while Y is positive in all cases, since R_n is always positive. Hence $\cos(y-\psi z)$ is always positive, and the elements of the first of the above integrals having thus the same value and the same sign for the same value of z, whether z be positive or negative, the value of the integral from $-\infty$ to $+\infty$ is the double of its value from 0 to ∞. On the other hand, since y and z have both the same sign, $\sin(y-\psi z)$ is positive or negative according as z is positive or negative, and the elements of the integral into which it enters being equal for $-z$ and $+z$, but having contrary signs, destroy each other, and the integral from $x=-\infty$ to to $x=+\infty$ vanishes. The expression for Q is therefore transformed into

$$Q=\frac{2}{\pi}\int_{0}^{\infty} Y\cos(y-\psi z)\sin\delta z.\frac{dz}{z}.$$

118. The formula now found cannot in general be integrated by any of the known methods, but in the present case the quantities denoted by Y and y are such that an approximate value of Q may be obtained, which will always be more nearly equal to the true value as h, the number of observations, is increased. On adding the squares of the two quantities represented by $R_n\cos r_n$ and $R_n\sin r_n$ we get

$$R_n^2=(\int\phi_n x\cos zx.dx)^2+(\int\phi_n x\sin zx.dx)^2.$$

If $z=0$, this becomes $R_n=\int\phi_n x dx$, whence by (116), $R_n=1$. When z has a real value, then it may be shewn that R_n is less than 1; for let x' be any value of A different from x, then as x' can only vary from as a to b, we have obviously,

$\int\phi_n x'\cos zx'.dx'=\int\phi_n x\cos zx.dx$, and $\int\phi_n x'\sin zx'.dx'=\int\phi_n x\sin zx.dx$,

and the above equation may be put under this form,

$$R^2{}_n=\int\phi_n x\cos zx.dx\int\phi_n x'\cos zx'dx'+\int\phi_n x\sin zx.dx\int\phi_n x'\sin zx'.dx,$$

whence

$$R^2{}_n=\iint\phi_n x\phi_n x'\cos z(x-x')dxdx'.$$

Now, excepting the case in which $z=0$, this double integral is always less than $\iint\phi_n x\phi_n x'dxdx'$, or less than $(\int\phi_n x dx)^2$, and consequently R_n is less than $\int\phi_n x dx$, that is, less than unity. Since, then, it has been shewn that R_n is equal to unity when $z=0$, and less than unity for all other values of z, and since Y is a quantity of the order R_n^h, it follows that Y must diminish with great rapidity when z, or its equal $\theta\div\epsilon$ differs sensibly from 0, and even for very small values of z becomes insensible when h is a large number. We may therefore assume $Y=e^{-\theta^2}$, an expression which is equal to unity when $\theta=0$, and diminishes rapidly as θ is increased, and becomes zero when θ is infinite.

119. For the sake of abridging let us assume

$$k_n=\int x\phi_n x dx,\ k'_n=\int x^2\phi_n x dx,\ k''=\int x^3\phi_n x dx,\ \&c.$$

(the integrals in respect of x being always from $x=a$ to $x=b$). From known formulæ we have

$$\cos zx=1-\frac{z^2x^2}{2}+\frac{z^4x^4}{2.3.4}-\&c.;\ \sin zx=zx-\frac{z^3x^3}{2.3}+\&c.;$$

substituting these series for $\cos zx$ and $\sin zx$ in the integrals $\int\phi_n x\cos zx.dx$ and $\int\phi_n x\sin zx.dx$, and also k_n, k'_n, k''_n, &c., for the values they have now been assumed to represent, then, from (116) we have

$$R_n\cos r_n=1-\frac{z^2}{2}k'_n+\frac{z^4}{2.4}k'''_n-\&c.$$

$$R_n\sin r_n=zk_n-\frac{z^3}{2.3}k''_n+\&c.$$

and it will be seen presently that all the terms involving higher powers of z than the cube may be neglected. Adding together the squares of these two equations, we get $R_n^2=1-z^2(k'_n-k^2_n)+z^4f-\&c.$; whence

$$R_n=1-\tfrac{1}{2}z^2(k'_n-k^2_n)+z^4f'-\&c.;$$

Probability. f' being independent of z. On dividing the second by the first, there results $\tan r_n = zk_n - \frac{1}{6}z^3k''_n + \frac{1}{2}z^3k_nk'_n -$ &c.; whence by reason of $r_n = \tan r_n - \frac{1}{3}\tan^3 r_n +$ &c.,

$$r_n = zk_n - \tfrac{1}{6}z^3(k''_n - 3k_nk'_n + 2k_n^3) + \text{&c.}$$

If, therefore, we make

$$c_n = \tfrac{1}{2}(k'_n - k^2_n),\ g_n = \tfrac{1}{6}z^3(k''_n - 3k_nk'_n + 2k_n^3),$$

the values of R_n and r_n become respectively

$$R_n = 1 - z^2c_n + z^4f' -\ \text{&c.};\ r_n = zk_n - z^3g_n +\ \text{&c.}$$

Now, by hypothesis (116) $Y = R_1 \times R_2 \times R_3 \ldots\ldots R_h$; therefore $\log Y = \Sigma \log R_n = \Sigma \log (1 - z^2c_n + z^4f' -$ &c.$) =$

$$-\Sigma\left\{z^2c_n - z^4(f' - \tfrac{1}{2}c_n) -\ \text{&c.}\right\}$$ (by reason of the formula $\log R_n = R_n - 1 - \frac{1}{2}(R_n - 1)^2 +$ &c.) But we have also assumed (117) $Y = e^{-\theta^2}$; hence $\log Y = -\theta^2$, and consequently

$$\theta^2 = \Sigma\left\{z^2c_n - z^4(f' - \tfrac{1}{2}c_n) -\ \text{&c.}\right\}$$ In like manner, since $y = r_1 + r_2 + r_3 \ldots + r_h = \Sigma r_n$, therefore $y = \Sigma zk_n - \Sigma z^3g_n +$ &c. Now, the sums Σ include all values of c_n, k_n, g_n, from $n=1$ to $n=h$; let the mean values of those quantities, therefore, be denoted by c, k, g, that is to say, let

$$\Sigma c_n = hc,\ \Sigma k_n = hk,\ \Sigma g_n = hg,$$

and make also $hf'' = \Sigma(f' - \frac{1}{2}c_n)$, and we have $\theta^2 = z^2hc - z^4hf'' +$ &c. By reverting the series the value of z is found in terms of θ; namely

$$z = \frac{\theta}{\sqrt{(hc)}} + \frac{f''\theta^3}{2hc^2\sqrt{(hc)}} +\ \text{&c.}$$

But the second term of this series, being divided by $h\sqrt{h}$, and h being by supposition a large number, is very small in comparison of the first, and may be neglected as insensible. All the succeeding terms of the series are divided by higher powers of h, and may therefore be rejected *a fortiori*. Confining the approximation, therefore, to terms of the order $1 \div \sqrt{h}$, and rejecting all those into which h or its powers enters as a divisor, we have $z = \theta \div \sqrt{(hc)}$, and likewise $dz \div z = d\theta \div \theta$.

From (116) we have also $y = \Sigma r_n = z\Sigma k_n - z^3\Sigma g_n +$ &c., therefore in consequence of the above transformations, $y = zhk - z^3hg +$ &c.; and on substituting for z its value just found in terms of θ, $y = k\theta\sqrt{(h \div c)} - g\theta^3 \div c\sqrt{(hc)}$, and consequently $y - \psi z = (hk - \psi)\theta \div \sqrt{(hc)} - g\theta^3 \div c\sqrt{(hc)}$. In order to deduce from this an expression for $\cos(y - \psi z)$, let u and v denote any two arcs, then by trigonometry, $\cos(u - v) = \cos u \cos v + \sin u \sin v$. Suppose v to be small, and let its cosine and sine be developed in series and substituted in this equation; it will become

$$\cos(u - v) = \cos u - \frac{v^2}{1.2}\cos u +\ \text{&c.} + v\sin u - \frac{v^3}{2.3}\sin u +\ \text{&c.}$$

whence, making $u = (hk - \psi)\theta \div \sqrt{(hc)}$, $v = g\theta^3 \div c\sqrt{(hc)}$, and rejecting as before terms of the order $1 \div h$, we have

$$\cos(y - \psi z) = \cos\left\{(hk - \psi)\frac{\theta}{\sqrt{(hc)}}\right\} + \frac{g\theta^3}{c\sqrt{(hc)}}\sin\left\{(hk - \psi)\frac{\theta}{\sqrt{(hc)}}\right\}.$$

If we now substitute the values of Y, z, dz, $\cos(y - \psi z)$ found in the last three paragraphs in the value of Q (117) we obtain the following expression in which the largest terms omitted are of the order $1 \div h$, and which therefore is more accurate as h is a higher number, viz.

$$Q = \frac{2}{\pi}\int_o^\infty e^{-\theta^2}\cos\left\{(hk - \psi)\frac{\theta}{\sqrt{(hc)}}\right\}\sin\frac{\delta\theta}{\sqrt{(hc)}}\cdot\frac{d\theta}{\theta}$$

$$+ \frac{2g}{\pi c\sqrt{(hc)}}\int_o^\infty e^{-\theta^2}\sin\left\{(hk - \psi)\frac{\theta}{\sqrt{(hc)}}\right\}\sin\frac{\delta\theta}{\sqrt{(hc)}}\cdot\theta^2 d\theta.$$

120. As no restriction has yet been made with respect to the value of ψ, excepting that it is a mean between $\mu\epsilon$ and $\nu\epsilon$, and therefore included between ha and hb (115), let us now assume $\psi = hk$. This gives $\cos(hk - \psi) = 1$, and $\sin(hk - \psi) = 0$; and the equation becomes

$$Q = \frac{2}{\pi}\int_o^\infty e^{-\theta^2}\sin\frac{\delta\theta}{\sqrt{(hc)}}\cdot\frac{d\theta}{\theta},$$ Probability.

which is the probability that the sum of the observed values of A will fall between $hk \mp \delta$.

121. The last step in this investigation is to reduce the integral now found to a known form, which may be accomplished as follows: Let u be a new variable, then by means of the trigonometrical formula $\cos u = \frac{1}{2}e^{u\sqrt{-1}} + \frac{1}{2}e^{-u\sqrt{-1}}$,

$$\int e^{-\theta^2}\cos u\theta . d\theta = \tfrac{1}{2}\int e^{-\theta^2 + u\theta\sqrt{-1}}\,d\theta + \tfrac{1}{2}\int e^{-\theta^2 - u\theta\sqrt{-1}}\,d\theta.$$

But $-\theta^2 + u\theta\sqrt{-1} = -\frac{1}{4}u^2 - (\theta - \frac{1}{2}u\sqrt{-1})^2$; assume therefore, $v = \theta - \frac{1}{2}u\sqrt{-1}$ (whence $dv = d\theta$), then

$$\tfrac{1}{2}\int e^{-\theta^2 + u\theta\sqrt{-1}}d\theta = \tfrac{1}{2}\int e^{-\frac{1}{4}u^2 - v^2}dv = \tfrac{1}{2}e^{-\frac{1}{4}u^2}\int e^{-v^2}dv.$$

When $\theta = 0$, then $v = -\frac{1}{2}u\sqrt{-1}$, and when θ is infinite, v is infinite; therefore, if the integral in respect of θ be taken from $\theta = 0$ to $\theta = \infty$, the integral in respect of v must be taken from $v = -\frac{1}{2}u\sqrt{-1}$ to $v = \infty$.

If we now suppose u to be negative, we shall have in like manner $\frac{1}{2}\int e^{-\theta^2 - u\theta\sqrt{-1}}d\theta = \frac{1}{2}e^{-\frac{1}{4}u^2}\int e^{-v^2}\,dv$, the limits in this case being from $v = +\frac{1}{2}u\sqrt{-1}$ to $v = \infty$. Hence

$$\int e^{-\theta^2}\cos u\theta . d\theta = \tfrac{1}{2}e^{-\frac{1}{4}u^2}\left(\int e^{-v^2}dv + \int e^{-v^2}dv\right).$$

But the sum of the two integrals on the right-hand side of this equation, the first being taken from $v = -\frac{1}{2}u\sqrt{-1}$ to infinity, and the second from $v = +\frac{1}{2}u\sqrt{-1}$ to infinity, is obviously the double of $\int e^{-v^2}dv$ from $v=0$ to $v = \infty$, or (96) equal to $\sqrt{\pi}$; and we have therefore

$$\int_o^\infty e^{-\theta^2}\cos u\theta . d\theta = \tfrac{1}{2}\sqrt{\pi}.e^{-\frac{1}{4}u^2}.$$

Let both sides of the equation be multiplied by du, and integrated from $u=0$ to $u = \delta \div \sqrt{(hc)} = u'$; then observing that $\int \cos(u\theta)d\theta = \sin(u\theta) \div \theta$, we shall have

$$\int_o^\infty e^{-\theta^2}\sin\frac{\delta\theta}{\sqrt{(hc)}}\cdot\frac{d\theta}{\theta} = \tfrac{1}{2}\sqrt{\pi}\int_o^{u'} e^{-\frac{1}{4}u^2}du.$$

Comparing this equation with that in (110), we find $Q = (1 \div \sqrt{\pi})\int_o^{u'} e^{-\frac{1}{4}u^2}du$. Now, let $u = 2t$, and let τ be what t becomes when $u = u' = \delta \div \sqrt{(hc)}$; then $\frac{1}{4}u^2 = t^2$, $du = 2dt$, $\delta \div \sqrt{(hc)} = 2\tau$, or $\delta = 2\tau\sqrt{(hc)}$, and we have, finally,

$$Q = \frac{2}{\sqrt{\pi}}\int_o^\tau e^{-t^2}dt, \text{ or, } Q = 1 - \frac{2}{\sqrt{\pi}}\int_\tau^\infty e^{-t^2}dt,$$

for the probability that s, the sum of the observed values of A, will be comprised between the limits $\psi - \delta$ and $\psi + \delta$, that is, between $hk \mp 2\tau\sqrt{(hc)}$; or, that the arithmetical mean of all the observations, namely $s \div h$, will lie between $k \mp 2\tau\sqrt{(c \div h)}$.

122. The expression now found for Q is that which in (96) was denoted by Θ, and of which the table gives the values corresponding to the different values of τ. The general result of the investigation is, therefore, that whatever be the nature of the function $\phi_n x$ which represents the law of the facility of the different values of A, if a large number of observations be made, the sum of the values of A, divided by the number of observations, approaches continually to a certain special quantity k (which is the true mean value of A) as the number of observations is increased, and that by multiplying the number of observations, a probability Θ may always be obtained, approaching as nearly to certainty as we please, that the difference between the arith-

Probability. metical mean or average of the observations and the true mean value of A, will be comprised within limits which may be made as small as we please.

The analysis employed in the preceding articles, (113 to 121), for the purpose of establishing this very important result, belongs to Poisson, and is given in nearly the same form in the *Recherches sur la Probabilité des Jugements*, chap. iv., and in the *Additions* to the *Connaissance des Tems* for 1832. We have preferred it to the method followed by Laplace in the *Théorie Analytique*, as being somewhat simpler and also more general.

123. In order that the limits $2\tau\sqrt{(hc)}$ may be real, it is necessary that the special quantity c be positive, a condition which has hitherto been assumed. Now, since $c=\Sigma c_n \div h$, it is obvious that c will be positive if $c_n=\frac{1}{2}(k'_n-k^2_n)$ be positive. On writing for k'_n and k_n their values (119) we have

$$2c_n=\int x^2\phi_n x dx-(\int x\phi_n x dx)^2,$$

the limits of the integrals being always from $x=a$ to $x=b$. But it is evident that no change will be made in the values of these definite integrals (the limits continuing the same), by substituting in them any other of the possible values of A, as x'. We have therefore $\int x'\varphi_n x' dx'=\int x\phi_n x dx$, and since in all cases $\int \phi_n x' dx'=1$, the above equation may be otherwise written

$$2c_n=\int x^2\phi_n x dx \int \varphi_n x' dx'-\int x\varphi_n x dx \int x'\varphi_n x' dx,$$

whence $2c_n=\iint \varphi_n x \varphi_n x' (x^2-xx')dxdx'$,

or $2c_n=\iint \varphi_n x \phi_n x' (x'^2-x'x)dxdx'$.

Adding together the two last equations, there results

$$4c_n=\iint \varphi_n x \phi_n x' (x-x')^2 dxdx',$$

a quantity which is necessarily positive, and can never be zero so long as x can have different values.

124. The special quantity k to which the average of the values of A continually approaches, is connected with the centre of gravity of the area of a curve by the following relation. Let x and y be the co-ordinates of a curve, of which the equation is $y=\phi_n x$; then the element of the area is $\phi_n x dx$. But (116) $\varphi_n x dx$ is the infinitely small probability that the value of A in the nth observation will lie between x and $x+dx$; therefore the element of the area of the curve represents this probability, and the curve itself represents the law of the probability of the different values of A in respect of the nth trial. In like manner, the curve whose co-ordinates are x and $(1\div h)\Sigma\varphi_n x$, represents the law of the mean probability of A in respect of the whole series of observations. Now, if x_1 be the abscis of the centre of gravity of any curve whose co-ordinates are x and y, the well known formula of mechanics gives $x_1=\int yx dx \div \int y dx$; therefore, applying this formula to the curve of the mean probability, and making the whole area ($\int y dx$ from $x=a$ to $x=b$)$=1$, the abscis of the centre of gravity is $x_1=(1\div h)\Sigma\int x\varphi_n x dx$. But this is the quantity denoted by k (119); hence the special quantity to which the average of a large number of observations indefinitely approaches is the abscis of the centre of gravity of the area of the curve which represents the law of the mean chances of A.

125. It has been assumed in the foregoing analysis that A is susceptible of an infinite number of values, increasing continuously from a to b. The results, however, are easily adapted to those cases in which the number of possible values of A is finite. Suppose A to be a thing susceptible of only λ different values, represented by $a_1, a_2, a_3 \ldots\ldots a_\lambda$, and let the chances of these values, which may be different in the different trials, be respectively $\gamma_1, \gamma_2, \gamma_3 \ldots\ldots \gamma_\lambda$ in respect of the nth trial. Now, suppose $\varphi_n x$ to be a discontinuous function, which vanishes for all values of x, of which the difference from one or other of the above values of A exceeds an infinitely small quantity ϵ; then the whole integral $\int \varphi_n x dx$ from $x=a$ to $x=b$, will be made up of a series of λ partial integrals $\int \varphi_n x dx$ taken between the limits $a_i \pm \epsilon$, the sum of which will be unity, since one or other of the values of A must necessarily be given by the trial. But the integral $\int \varphi_n x dx$ between the limits $a_i \pm \epsilon$ is the expression of the chance that the value of A given in the nth trial will lie between $a_i \pm \epsilon$; whence for those limits $\int \varphi_n x dx=\gamma_i$. Now the difference $x-a_i$ must be infinitely small, since it cannot exceed ϵ; we may therefore substitute a_i for x, and a_i^2 for x^2 under the sign of integration, when the limits are $a_i \pm \epsilon$, so that for those limits we have $\int x\varphi_n x dx=a_i \int \varphi_n x dx=\gamma_i a_i$. On writing for i all the different numbers $1, 2, 3 \ldots\ldots \lambda$, and observing that the λ partial integrals thus formed make up the whole integral $\int x\varphi_n x dx$ from $x=a$ to $x=b$, and that therefore their sum is k_n, we have, in respect of the nth trial,

$$k_n=\gamma_1 a_1+\gamma_2 a_2+\gamma_3 a_3 \ldots\ldots+\gamma_\lambda a_\lambda.$$

In like manner, for $k'_n=\int x^2 \varphi_n x dx$ (from a to b), we have

$$k'_n=\gamma_1 a_1^2+\gamma_2 a_2^2+\gamma_3 a_3^2 \ldots\ldots+\gamma_\lambda a_\lambda^2;$$

so that the two special quantities k and k' become

$$k=(1\div h)\Sigma(\gamma_1 a_1+\gamma_2 a_2+\gamma_3 a_3 \ldots\ldots+\gamma_\lambda a_\lambda),$$

$$k'=(1\div h)\Sigma(\gamma_1 a_1^2+\gamma_2 a_2^2+\gamma_3 a_3^2 \ldots\ldots+\gamma_\lambda a_\lambda^2),$$

the sums Σ extending to all the h values of n, or to all the trials, the chances denoted by γ_1, γ_2, &c. being supposed to vary in the different trials.

126. When the chances of the different values of A are equal and constant, then $\gamma_i=1\div\lambda$, and the above values of k and k' become

$$k=(1\div\lambda)(a_1+a_2+a_3 \ldots\ldots+a_\lambda),$$

$$k'=(1\div\lambda)(a_1^2+a_2^2+a_3^2 \ldots\ldots+a_\lambda^2),$$

so that k is the arithmetical mean of the possible values of A, and k' the mean of the squares of those values. On this hypothesis, therefore, k and k' may be computed *a priori*, and consequently the limits determined within which there is a given probability Θ that the average of h observations will fall, the limits being $k \pm 2\tau\sqrt{(c\div h)}$, where $c=\frac{1}{2}(k'-k^2)$.

When the chances of the different values of A are unequal, but constant in the different trials, then $k=k_n$, and $k'=k'_n$, and we have

$$k=\gamma_1 a_1+\gamma_2 a_2+\gamma_3 a_3 \ldots\ldots+\gamma_\lambda a_\lambda,$$

$$k'=\gamma_1 a_1^2+\gamma_2 a_2^2+\gamma_3 a_3^2 \ldots\ldots+\gamma_\lambda a_\lambda^2.$$

In this case the special quantity k to which the average of the observed values continually approaches, is the sum of the possible values, each multiplied into its respective probability; and k' is the sum of the products of the squares of those values into their respective probabilities.

127. Resuming the consideration of the general formula in (121), we shall now give an example of its application when the function which represents the law of facility of the different values of A is supposed to be known *a priori*.

Of all the hypotheses which may be made respecting the law of facility, the simplest is that which supposes the chances of all the possible values of the thing observed to be equal, and to remain constant during the series of trials. This supposes $\varphi_n x=\varphi x=$ a constant; whence $\int \varphi x dx$, between the limits $x=a$ and $x=b$, becomes $(b-a)\varphi x$. But between those limits we have also $\int \varphi x dx=1$; therefore $\varphi x=1\div(b-a)$. From this value of φx it is easy to deduce the special quantities k and k'. On the present hypothesis $k=k_n$ and $k'=k'_n$; therefore, the limits of the integral being $x=a$ and $x=b$, we have $k=\int x\varphi x dx=\int \frac{x dx}{b-a}=\frac{b^2-a^2}{2(b-a)}=\frac{1}{2}(b+a)$, whence $k^2=\frac{1}{4}(b+a)^2$. In like manner $k'=\int x^2 \varphi x dx$ becomes $\int \frac{x^2 dx}{b-a}=\frac{1}{3}(b^2+ba+a^2)$; whence $c=\frac{1}{2}(k'-k^2)$

Probability. $=\frac{1}{6}(b^2+ba+a^2)-\frac{1}{8}(b+a)^2$. Hence by (121) we have the probability Θ that the average value of A given by h observations, or the sum of the values of A divided by their number, will lie between

$$\tfrac{1}{2}(b+a) \mp 2\tau\sqrt{\{\tfrac{1}{6}(b^2+ba+a^2)-\tfrac{1}{8}(b+a)^2\}} \div \sqrt{h}.$$

128. This formula may be applied to the following question. Of the comets which have been observed since the year 240 of our era, the parabolic elements of 138 have been computed, and the mean inclination of their orbits to the ecliptic is found to be 48° 55′. Now, supposing every possible inclination of an orbit to be equally probable, let the probability be demanded that the mean inclination of 138 orbits will not differ from 45° (the mean of the possible inclinations) more than 5° in excess or defect.

In this case the limits of the possible values of the phenomenon are 0 and 90°. We have therefore $a=0$, $b=90°$, $h=138$, and the above limits of the error of the average, become $45° \mp \tau \times 90° \div \sqrt{(6 \times 138)}$. In order that the limits may not exceed 5°, we have to determine τ from the equation $\tau \times 90° \div \sqrt{(6 \times 138)} = 5°$, which gives $\tau = \frac{1}{3}\sqrt{23}$; whence $\tau = 1{\cdot}6$ very nearly. The tabular value of Θ corresponding to $\tau = 1{\cdot}6$ is ·97635, or nearly $\frac{41}{42}$; and the odds are therefore 41 to 1 that on the supposition of all inclinations being equally probable, the mean inclination of 138 comets would fall between $45° \mp 5°$, that is, between 40° and 50°. The mean of the inclinations actually computed falls within those limits (being 48° 45′); there is therefore a very great probability that whatever may be the nature of the unknown causes which determine the positions of the cometary orbits, it is not such as to render different inclinations unequally probable.

If the question had been to assign the limits within which it is as probable that the mean of the inclinations will fall as not, we should have had $\Theta = \frac{1}{2}$, and consequently (from the table) $\tau = {\cdot}476936$, and the limits would have been $45° \mp 90° \times {\cdot}476936 \div \sqrt{(6 \times 138)}$, which is found on calculation to be $45° \mp 1°{\cdot}5$. On the supposition, therefore, that all inclinations are equally probable, it is one to one that the mean of 138 inclinations will fall between $43\frac{1}{2}°$ and and $46\frac{1}{2}°$, or at least not exceed those limits.

129. On the same hypothesis of an equal probability of all possible values, if we suppose the mean value of A to be 0, we have then $a=-b$, and φx becomes $1 \div 2a$, whence the limits corresponding to a given value of Θ (127) become $0 \mp 2\tau b : \sqrt{(6h)}$. Let $\Theta = \frac{1}{2}$, whence $\tau = {\cdot}476936$, and suppose $h=600$. With these values the limits become $0 \mp {\cdot}016b$ nearly; that is to say, it is an even wager that the average of 600 observations will not differ from the true mean value of A more than the sixteen-thousandth part of a or b, what is the greatest possible difference.

130. As a second hypothesis, suppose the chance of a given value of A to decrease uniformly as the magnitude increases from 0 to $\pm a$; then φx will be found as follows: Let $\varphi x = \beta$ when $a=0$; we have then by the hypothesis $\varphi x : \beta = (a-x) : a$, whence $\varphi x = (a-x)\beta \div a$, and consequently $\int \varphi x dx = \beta x - \beta x^2 \div 2a$, which, from $x=0$ to $x=+a$, becomes $\frac{1}{2}\beta a$. But $\int \phi x dx$ from $x=-a$ to $x=+a$ is 1 (errors beyond those limits being supposed impossible), therefore from $x=0$ to $x=+a$, $\int \phi x dx = \frac{1}{2}$, and consequently $\frac{1}{2}\beta a = \frac{1}{2}$, or $\beta = 1 \div a$. Hence $\phi x = (a-x) \div a^2$, from which the value of c is easily deduced, that of k being 0, as in the former case.

131. Although the function φx which represents the law of facility of the different values of A is in general unknown, its form may be assigned if we assume that it is subject to certain conditions, which, from the nature of the thing, must be very nearly, if not absolutely true, in most practical cases: 1st, That the chance of an error diminishes as the magnitude of the error increases, and for errors beyond a certain limit vanishes altogether; and, 2d, that positive and negative errors, of equal magnitude, are equally probable. The last condition is equivalent to the assumption that the average of the observed values is the true mean value. For simplification, we suppose the chance of an error of a given magnitude to remain constant in all the trials.

132. Let x, x', x'', &c. be a series of values of A, the sum of which is s, and the number h, and make $m = s \div h$, then m is the arithmetical mean or average, which by hypothesis is the true value of the phenomenon A. Let $x-m=\Delta$, $x'-m=\Delta'$, $x''-m=\Delta''$, &c., so that Δ, Δ', Δ'', &c. are the errors of x, x', x'', &c. Now, the most probable single error is 0; and the probability of obtaining an error of a given magnitude Δ in any observation is obviously the same as that of obtaining a given value of x; therefore $\varphi x = \varphi(x-m) = \varphi\Delta$; so that $\varphi\Delta$ is the probability of a single error being exactly Δ. In like manner, the probability of an error ror $=\Delta'$ is $\varphi\Delta'$; and if we take P to denote the probability of a given system of errors, Δ, Δ', Δ'', &c., then the errors being supposed independent of each other, we have (7)

$$P = \varphi\Delta \,.\, \varphi\Delta' \,.\, \varphi\Delta'', \text{ &c.}$$

Let this system be assumed to be the most probable result of the observations, then P is a maximum, and its differential co-efficient zero. Taking the logarithms of both sides of the equation, differentiating, and making $d \log.\varphi\Delta = \varphi'\Delta d\Delta$, and $dP \div d\Delta = 0$, we obtain

$$0 = \varphi'\Delta + \varphi'\Delta' + \varphi'\Delta'' +, \text{ &c.,}$$

an equation which may be otherwise written

$$0 = \Delta\frac{\varphi'\Delta}{\Delta} + \Delta'\frac{\varphi'\Delta'}{\Delta'} + \Delta''\frac{\varphi'\Delta''}{\Delta''} +, \text{ &c.}$$

This is the conditional equation of the most probable system of errors. But the hypothesis of the average being the true value, furnishes this other equation,

$$0 = (x-m) + (x'-m) + (x''-m) +, \text{ &c.}$$

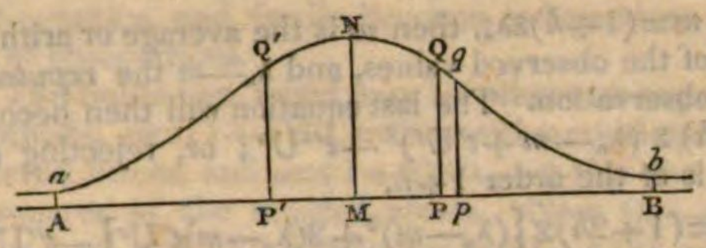
or, which is the same, $0 = \Delta + \Delta' + \Delta'' +$, &c.; and on comparing this with the above conditional equation, it is evident that they can only be both true simultaneously on the supposition of $\frac{\varphi'\Delta}{\Delta} = \frac{\varphi'\Delta'}{\Delta'} = \frac{\varphi'\Delta''}{\Delta''} =$, &c. Hence it follows that $\varphi'\Delta \div \Delta$ is independent of any particular value of Δ, or is equal to a constant, which we shall call K. We have then

$$\frac{\varphi'\Delta}{\Delta} = \frac{d \,.\, \log.\,\varphi\Delta}{\Delta d\Delta} = K.$$

The integral of this expression is $\log.\varphi\Delta = \frac{1}{2}K\Delta^2 +$ const., which, making the last constant $=\log.H$, and passing to numbers, gives $\varphi\Delta = He^{\frac{1}{2}K\Delta^2}$. It now only remains to determine the two constants H and K. With respect to K, as we suppose the most probable value of Δ to be 0, and that $\varphi\Delta$ diminishes as Δ increases, it is obvious that K must be negative. Assume $\frac{1}{2}K = -\gamma$, and the formula becomes $\varphi\Delta = He^{-\gamma\Delta^2}$. For the determination of H we have the equation $\int \varphi\Delta d\Delta = 1$, the limits of the integral being $-a'$ and $+a'$, where $a' = \frac{1}{2}(b-a)$, a and b being the limiting values of x. But it is to be observed, that as all values of Δ exceeding the limits $\pm a'$ are supposed to be impossible, or at least to be so improbable that it is unnecessary to take account of them, the value of the integral $\int \varphi\Delta d\Delta$ from $\Delta = -a'$ to $\Delta = +a'$ will not be altered by extending the limits from — infinity to + infinity. We have therefore $\int_{-\infty}^{+\infty} \varphi\Delta d\Delta = 1$. Let $\Delta = t \div \sqrt{\gamma}$, then $d\Delta = dt \div \sqrt{\gamma}$, and $\varphi\Delta = He^{-\gamma\Delta^2} = He^{-t^2}$, on substituting which in the las equation, and observing that from $t=-\infty$ to $t=+\infty$ we have $\int e^{-t^2}dt = \sqrt{\pi}$ (96), we find $(H \div \sqrt{\gamma})\sqrt{\pi} = 1$, and $H = \sqrt{(\gamma \div \pi)}$. Whence, finally, $\varphi\Delta = \sqrt{(\gamma \div \pi)}e^{-\gamma\Delta^2}$.

133. The general properties of the function now found

Probability. may be illustrated by means of a curve line. Let aNb be



a curve of which $\varphi\Delta$ is the ordinate corresponding to the absciss Δ. Let AB be its axis, and MN its greatest ordinate. Suppose the origin to be placed at M, draw PQ an ordinate at any point P, and pq indefinitely near to PQ, and make MB$=a'$, MA$=-a'$, MP$=\Delta$, and PQ$=\varphi\Delta$; then as was shewn in (124), PQqp, the element of the area, represents the chance of an error lying between Δ and $\Delta+d\Delta$, that is, of an error greater than MP but less than Mp. Now, if $\varphi\Delta=\sqrt{(\gamma\div\pi)}e^{-\gamma\Delta^2}$ the function will not be changed by changing Δ into $-\Delta$; therefore $\varphi\Delta=\varphi(-\Delta)$, and the curve is symmetrical on both sides of MN, as it obviously ought to be according to the hypothesis; for on making MP′=MP, then positive and negative errors of equal magnitude being equally probable, we must have P′Q′=PQ. Again, since $e^{-\gamma\Delta^2}$ diminishes rapidly as Δ increases, the curve at a short distance from MN must approach very near to its axis AB; but as the function only vanishes when Δ is infinite, the curve will not meet the axis at any finite distance from MN. This curve, therefore, can only represent approximately the law of facility, inasmuch as it is supposed that errors beyond a certain limit are impossible; but on account of the rapid diminution of the ordinate at a short distance from MN, the chance of an error exceeding a small value of Δ, as MB, becomes insensible. Hence the limits of the integrals in respect of Δ may be extended without sensibly altering their values from $\Delta=\pm a'$ to $\Delta=\pm\infty$.

134. It is now necessary to find the special quantities k, k', and c. Substituting Δ for x, and observing that as the law of the chances is here supposed to remain constant, we have $k=k_n$, $k'=k'_n$, the formulæ in (119) become $k=\int\Delta\varphi\Delta d\Delta$, $k'=\int\Delta^2\varphi\Delta d\Delta$. Hence on making $\varphi\Delta=\sqrt{(\gamma\div\pi)}e^{-\gamma\Delta^2}$, we have

$$k=\sqrt{\frac{\gamma}{\pi}}\int\Delta e^{-\gamma\Delta^2}d\Delta=\sqrt{\frac{\gamma}{\pi}}\cdot\frac{1}{2\gamma}\int d.e^{-\gamma\Delta^2}=\frac{1}{2\sqrt{(\gamma\pi)}}e^{-\gamma\Delta^2}.$$

When Δ becomes infinite, this becomes 0, therefore from $\Delta=-\infty$ to $\Delta=+\infty$, $k=0$. This is an obvious consequence of the symmetry of the curve, for the centre of gravity is necessarily in the straight line MN.

With respect to k' we may proceed thus. We have $k'=\int\Delta^2\phi\Delta d\Delta=\sqrt{(\gamma\div\pi)}\int\Delta^2e^{-\gamma\Delta^2}d\Delta$. But from the principles of the differential calculus,

$$d\,.\,\Delta e^{-\gamma\Delta^2}=e^{-\gamma\Delta^2}d\Delta-2\gamma\Delta^2e^{-\gamma\Delta^2}d\Delta,$$

therefore, integrating and transposing,

$$\int\Delta^2e^{-\gamma\Delta^2}d\Delta=-\frac{1}{2\gamma}\Delta e^{-\gamma\Delta^2}+\frac{1}{2\gamma}\int e^{-\gamma\Delta^2}d\Delta.$$

Now, from $\Delta=-\infty$ to $\Delta=+\infty$, the term of this equation which is not under the sign of integration vanishes, and $\int e^{-\gamma\Delta^2}d\Delta=\sqrt{(\pi\div\gamma)}$ (from (96), on substituting t^2 for $\gamma\Delta^2$), therefore $\int\Delta^2e^{-\gamma\Delta^2}d\Delta=(1\div2\gamma)\sqrt{(\pi\div\gamma)}$; and consequently $k'=1\div2\gamma$.

In (119) we assumed $c=\frac{1}{2}(k'-k^2)$; therefore in the present case $c=\frac{1}{2}k'$, whence $c=1\div4\gamma$, or $\gamma=1\div4c$.

135. The expressions which have now been found for the function which represents the probability of an error, and the limits corresponding to an assigned degree of probability, are given in terms of the indeterminate constant γ (or c), which depends on the nature of the observation, and therefore, where instruments are requisite, on the goodness of the instrument and the skill of the observer. This constant is called by Laplace the *modulus* of the law of facility. Probability.
It cannot, in general, be assigned *a priori*; but if we assume that positive and negative departures from the mean are alike probable, which is the most plausible hypothesis the nature of the thing admits of, an approximation to its value, in respect of observations of a given kind, may be deduced with great probability from the results of a large series of observations of the same kind already made. We now proceed to give the analysis by which this is accomplished, following the method of Poisson. The approximation is carried only to quantities of the order $1\div\sqrt{h}$; terms having h for a divisor are neglected on account of their smallness, h being supposed a large number.

136. In the expression for Q in (119), suppose $\psi=\delta$, and consequently $\psi-\delta=0$, $\psi+\delta=2\delta$, and write also z for $\theta\div\sqrt{(hc)}$; the equation then becomes

$$Q=\frac{2}{\pi}\int_o^\infty e^{-\theta^2}\cos(hkz-\delta z)\sin\delta z\,.\,\frac{\delta\theta}{\theta}$$
$$+\frac{2g}{\pi c\sqrt{(hc)}}\int_o^\infty -\theta^2\sin(hkz-\delta z)\sin\delta z\,.\,\theta^2d\theta,$$

and Q is the probability that s, the sum of the values of A given by all the observations, will lie between 0 and 2δ. If therefore, we suppose δ to be variable, the differential of this expression taken with respect to δ, will express the infinitely small chance of the sum of the values being 2δ exactly. Differentiating, and observing that if u and v denote any two arcs, the trigonometrical formulæ give

$$\sin(u-v)\sin v+\cos(u-v)\cos v=\cos(2v-u),$$
$$-\cos(u-v)\sin v+\sin(u-v)\cos v=-\sin(2v-u),$$

we shall find

$$\frac{dQ}{d\delta}d\delta=\frac{2d\delta}{\pi}\int_o^\infty e^{-\theta^2}\cos(2\delta z-hkz)\frac{zd\theta}{\theta}$$
$$-\frac{2gd\delta}{\pi c\sqrt{(hc)}}\int_o^\infty e^{-\theta^2}\sin(2\delta z-hkz)z\theta^2d\theta.$$

Let t be a variable quantity, and assume $2\delta=hk+2t\sqrt{(hc)}$, whence $d\delta=dt\sqrt{(hc)}$, and let the corresponding value of $\frac{dQ}{d\delta}d\delta$ be denoted by qdt, we shall have, on substituting these values, and replacing z by $\theta\div\sqrt{(hc)}$, $qdt=\frac{2dt}{\pi}$

$$\int_o^\infty e^{-\theta^2}\cos(2t\theta)\,d\theta-\frac{2gdt}{\pi c\sqrt{(hc)}}\int_o^\infty e^{-\theta^2}\sin(2t\theta)\theta^3d\theta.$$

The two integrals in this equation are found from the formula in (121). Writing $2t$ for u, that formula gives

$$\int_o^\infty e^{-\theta^2}\cos(2t\theta)d\theta=\tfrac{1}{2}\sqrt{\pi}\,.\,e^{-t^2};$$

and if this last equation be differentiated in respect of t, three times in succession, the result will be

$$\int_o^\infty e^{-\theta^2}\sin(2t\theta)\theta^3d\theta=\tfrac{1}{4}\sqrt{\pi}(3te^{-t^2}-2t^3e^{-t^2});$$

whence, if we make $V=\frac{g}{2c\sqrt{(hc)}}(3t-2t^3)$, we shall have

$$qdt=(1\div\sqrt{\pi})(1-V)e^{-t^2}dt,$$

where V is a quantity containing only uneven powers of t, and of the order $1\div\sqrt{h}$, so that when multiplied by another of the same order, the product will be of the order $1\div h$, and will therefore be rejected in the present approximation. This value of qdt is the probability that s will be precisely 2δ or $hk+2t\sqrt{(hc)}$, or it is the infinitely small probability of the equation

$$s=hk+2t\sqrt{(hc)}.$$

137. In order to apply this result to the determination of the probable limits in terms of observations actually

Probability. made, it is necessary to remark that the analysis by means of which it has been obtained is grounded on the very general supposition that the thing to be measured may be any function whatever of the quantity observed; for the infinitely small chance of a particular value of the function is evidently the same as that of the corresponding value of the quantity, and is consequently $\phi_n x dx$. Let X therefore be a function of x, and let K, C, T, be what k, c, t become when X is substituted for x, the above equation then becomes

$$\Sigma X = hK + 2T\sqrt{(hC)},$$

the symbol Σ including all the h values of X; and the probability of this equation is an expression of the same form as that which is represented by qdt.

138. Hitherto no restriction has been made with respect to ϕx; we now introduce the hypothesis that positive and negative departures from the mean of equal magnitude are equally probable, and consequently that the curve representing the law of facility is symmetrical, but shall suppose the chances of a particular value, or a particular error, to vary in the different trials. Let the origin be transferred to the centre of gravity, the abscis of which $= k$, and let $x - k = \Delta$, $x' - k = \Delta'$ &c. We have then by (132) $\phi x = \phi\Delta$, $\int x\phi x dx = \int \Delta\phi\Delta d\Delta$, $\int x^2\phi x dx = \int \Delta^2\phi\Delta d\Delta$, the integration in respect of Δ being from $-\infty$ to $+\infty$. The special quantities k and k' then become $k = (1\div h)\Sigma\int\Delta\phi_n\Delta d\Delta = 0$, $k' = (1\div h)\Sigma\int\Delta^2\phi_n\Delta d\Delta$, whence

$$c = (1\div 2h)\Sigma\int\Delta^2\phi_n\Delta d\Delta.$$

The object is now to eliminate $\phi_n\Delta$, and determine c in terms of the observations.

139. Let $\lambda_n = x$ be the observed value of A in the nth observation, then $\lambda_n - k = \Delta$ is the true error of the observation. Let the function denoted by X in (137) be $(\lambda_n - k)^2 = \Delta^2$, and the corresponding value of K (since in this case, $K = (1\div h)\Sigma\int X\phi_n x dx$) becomes $K = (1\div h)\Sigma\int\Delta^2\phi_n\Delta d\Delta$. Comparing this with the value of c found above, we have $K = 2c$; therefore on substituting these values of X and K in the equation (137), and assuming t' and c' to be the values of T and C when $X = (\lambda_n - k)^2$, we get $\Sigma(\lambda_n - k)^2 = 2hc + 2t'\sqrt{(hc')}$, whence

$$c = (1\div 2h)\Sigma(\lambda_n - k)^2 - t'U' \qquad (1)$$

(U being a quantity of the order $1\div\sqrt{h}$); and the probability of this equation is

$$q'dt' = (1\div\sqrt{\pi})(1 - V')e^{-t'^2}dt',$$

where V′ is a function containing only uneven powers of t', and of the order $1\div\sqrt{h}$.

In the equation (137) suppose $X = x = \lambda_n$, and let t'' and c'' be the corresponding values of T and C, then since on this supposition $K = k$, the equation becomes $\Sigma\lambda_n = hk + 2t''\sqrt{(hc'')}$, whence

$$k = (1\div h)\Sigma\lambda_n - t''U'', \qquad (2)$$

(U″ being of the order $1\div\sqrt{h}$); and the probability of this equation is

$$q''dt'' = (1\div\sqrt{\pi})(1 - V'')e^{-t''^2}dt'',$$

where V″, like V′ and V, contains only uneven powers of t'' and is of the order $1\div\sqrt{h}$.

140. The two equations (1) and (2) may be regarded as two distinct events, having the respective probabilities now assigned to them, and therefore the probability of their being true simultaneously is the product of their respective probabilities, and is accordingly (neglecting the product V′V″ which is a quantity divided by h),

$$q'q''dt'dt'' = (1\div\pi)(1 - V' - V'')e^{-t'^2}e^{-t''^2}dt'dt''.$$

Let the value of k given by equation (2) be substituted in (1), and the expression now given will accordingly be the probability of the resulting equation, namely,

Probability.

$$c = \frac{1}{2h}\Sigma(\lambda_n - \frac{1}{h}\Sigma\lambda_n + t'U')^2 - t''U''.$$

Let $m = (1\div h)\Sigma\lambda_n$, then m is the average or arithmetical mean of the observed values, and $\lambda_n - m$ the *reputed* error of the observation. The last equation will then become $c = (1\div 2h)\Sigma(\lambda_n - m + t'U')^2 - t''U''$; or, rejecting $(t'U')^2$ which is of the order $1\div h$,

$$c = (1\div 2h)\Sigma\{(\lambda_n - m)^2 + 2(\lambda_n - m)t'U'\} - t''U''.$$

For the sake of abridging let us also assume

$$\mu = (1\div h)\Sigma(\lambda_n - m)^2,\ \nu = (1\div h)\Sigma(\lambda_n - m)t',$$

so that μ is the mean of the squares of the errors, or *mean square* of the errors, and the equation becomes

$$c = \tfrac{1}{2}\mu + \nu U' - t''U'', \qquad (3)$$

the probability of which is $q'q''dt'dt''$.

141. Now, by (121), we have the probability Θ that $s\div h$, or $\Sigma\lambda_n\div h = m$ the arithmetical mean of the observed values of A, will fall within the limits $k \mp 2\tau\sqrt{(c\div h)}$. Substituting in those limits the above value of c, and observing that $(\frac{1}{2}\mu + \nu U' - t''U'')^{\frac{1}{2}} = \sqrt{(\frac{1}{2}\mu)} + N(\nu U' - t''U'') + $ &c., and that U′ and U″ being of the order $1\div\sqrt{h}$, when divided again by $\sqrt{h}$ are to be rejected, the limits become

$$k \mp 2\tau\sqrt{(\tfrac{1}{2}\mu\div h)},\ \text{or}\ k \mp \tau\sqrt{(2\mu\div h)},$$

and the probability of these being the true limits is Θ multiplied into the probability of the equation $c = \frac{1}{2}\mu + \nu U' - t''U''$; and is therefore (140)

$$(1\div\pi)\Theta(1 - V' - V'')e^{-t'^2}e^{-t''^2}dt'dt''.$$

142. The expression now obtained is the infinitely small probability of the limits $k \mp \tau\sqrt{(2\mu\div h)}$ of the average m, in respect of the particular value of s, for which we have deduced the equation (3). But for every value of s between the limits 0 and 2δ, there will be an equation corresponding to (3); therefore, in order to have the whole probability of those limits, the integral of the expression must be found for all values of t' and t''. From the nature of the expressions $e^{-t'^2}$ and $e^{-t''^2}$ as well as the consideration that errors beyond a certain magnitude, though possible, are wholly improbable, it is evident that the integration may be extended without sensible error from $-\infty$ to $+\infty$; and since the functions V′ and V″ contain only uneven powers of t' and t'', the terms into which they enter, disappear in the integrations between those limits (See Lacroix, *Calcul Diff. et Integral*, tom. iii. p. 506). Now, from $t' = -\infty$ to $t' = +\infty$ we have (96) $\int e^{-t'^2}dt' = \sqrt{\pi}$; and $\int e^{-t''^2}dt'' = \sqrt{\pi}$; therefore

$$\frac{1}{\pi}\Theta\iint(1 - V' - V'')e^{-t'^2}e^{-t''^2}dt'dt'' = \Theta.$$

The result of the preceding analysis is therefore that on the hypothesis of positive and negative errors of equal magnitude being equally probable, and on rejecting terms divided by h (the number of the observations may be always so great as to render such terms insensible), we may substitute $\frac{1}{2}\mu$ for c in the limits of the error to be apprehended, without sensibly altering the probability, and consequently there is the probability $\Theta = \frac{2}{\sqrt{\pi}}\int_0^\tau e^{-t^2}dt$ that the true mean value k of the phenomenon A will lie between the limits

$$m \mp 2\tau\sqrt{(\tfrac{1}{2}\mu\div h)},\ \text{or}\ m \mp \tau\sqrt{(2\mu\div h)},$$

which contain only quantities given by observation.

On this hypothesis we have also (138) $c = (1\div 2h)\Sigma\int\Delta^2\phi_n\Delta d\Delta$, or, supposing the law of facility to remain constant during the trials, $c = \frac{1}{2}\int\Delta^2\phi\Delta d\Delta$, therefore $\mu = \int\Delta^2\phi\Delta d\Delta$; that is to say, the mean of the squares of the actual errors may be taken for the sum of the products of the squares of the possible errors multiplied by their respective

Probability. probabilities. It is important to remark that as the observations become more numerous, the quantity μ, the mean of the squares of the errors, converges more and more to a constant quantity, and finally becomes independent of the number of observations.

143. The limits now found may be otherwise expressed. By hypothesis, $m=(1\div h)\Sigma\lambda_n$=the arithmetical mean of the observed values, and $\mu=(1\div h)\Sigma(\lambda_n-m)^2=$ the mean of the squares of the reputed errors. Now $(\lambda_n-m)^2=\lambda_n{}^2-2\lambda_n m+m^2$, and $(1\div h)\Sigma 2\lambda_n m=2m(1\div h)\Sigma\lambda_n=2m^2$; therefore $\mu=(1\div h)\Sigma\lambda_n{}^2-m^2$, that is to say, the mean of the squares of the observations minus the square of the mean. Hence the limits, corresponding to a given probability Θ, of the difference between the average of all the observations and the true value, are expressed by either of these formulæ

$$\pm\tau\sqrt{\{(2\times \text{mean square of errors}\div h\}},$$

$$\pm\tau\sqrt{\{2\times \text{mean square of obs.}-(\text{mean of obs.})^2\}}\div\sqrt{h},$$

h being the number of observations, and the relation between Θ and τ being given by the table. Generally speaking, the first of these formulæ is the most convenient for calculation.

144. Let l be the limit of the error to be feared in taking the average of the observations as the true result, then $l=\tau\sqrt{(2\mu\div h)}$, and $\tau=l\sqrt{(h\div 2\mu.)}$ Now when τ is constant, that is, for a given probability Θ, the determination will be more exact in proportion as l is a smaller number, and the precision will therefore be proportional to $\sqrt{(h\div 2\mu)}$. Hence $\sqrt{(h\div 2\mu)}$ is called by Gauss the *measure of the precision* of the determination. Suppose two series of observations to have been made for the determination of an element, the comparative accuracy of the results will depend on two things, the number of observations in each series, and the amount of the squares of the errors in each. If the number of observations is the same in both series, the precision of each result will be inversely as the square root of the sum of the squares of the errors, and the presumption of accuracy is in favour of that result with respect to which the sum of the squares of the errors is less than in the other. On the other hand, if the mean square of the errors is the same in both series, then the observations are alike good in both, and their relative values of the two results are directly as the square roots of the number of observations in each series. Hence, in order that one determination may be twice as good as another, it must be founded on four times the number of equally good observations. These considerations are very important, in comparing tables of mean values of whatever kind, for example, of the probabilities of life at the different ages, and in estimating risks which depend upon them.

145. Astronomers employ the terms, *weight*, *probable error*, and *mean error*, of a result, to denote certain functions of μ, the mean square of the errors. The square of the quantity which measures the precision of the result, is called the *weight* of the determination. Denoting the weight by w, we have therefore

$$w=h\div 2\mu=h^2\div 2\Sigma(\lambda_n-m)^2,$$

or the weight is equal to the square of the number of observations divided by twice the sum of the squares of the errors. Substituting this in the expression of the limits, we have $l=\tau\div\sqrt{w}$, and $\tau=l\sqrt{w}$; that is to say, for a given probability Θ, the limits of the error to be apprehended in taking the average as the true result are reciprocally proportional to the square root of the weight. When observations of different kinds, or results deduced from observation, are compared with each other, their relative weights (supposing the number of observations the same) are inversely as μ, and are expressed numerically by taking the weight of a certain series of observations as the unit of weight.

146. The *probable error* of the determination is that which corresponds to the probability $\Theta=\frac{1}{2}$. For $\Theta=\frac{1}{2}$ we have $\tau=\cdot 476936$; whence $\tau\sqrt{2}=\cdot 674489$, and the formula $m\pm\tau\sqrt{(2\mu\div h)}$ becomes $m\pm\cdot 674489\sqrt{(\mu\div h)}$; whence Probability.

$$\text{probable error}=\cdot 674489\sqrt{(\mu\div h)}.$$

147. The *mean error* of the result of a large number of observations may be deduced from the general formula in (136) as follows. That formula gives $qdt=(1\div\sqrt{\pi})(1-V)e^{-t^2}dt$ for the probability that the sum of the observed values will be $2\delta=hk+2t\sqrt{(hc)}$ exactly. Dividing the sum by h, qdt is also the probability that the average value given by all the observations will be exactly $k+2t\sqrt{(c\div h)}$. Now, on the hypothesis that positive and negative departures from the mean are equally probable, and supposing the origin of the co-ordinates to be transferred to the centre of gravity of the curve of mean probability, we have $k=0$, and $qdt=(1\div\sqrt{\pi})(1-V)e^{-t^2}dt$ is the infinitely small chance of the average error being $2t\sqrt{(c\div h)}$ exactly. Multiplying therefore this error into the chance of its taking place, and integrating the product from $t=0$ to $t=\infty$, we shall have the *mean* error, or *mean risk* of all the possible average errors affected with the positive sign. Now, observing that V represents a quantity divided by $\sqrt{h}$, and therefore when multiplied by $2t\sqrt{(c\div h)}$ becomes of the order $1\div h$, and may consequently be rejected, the product of the average error $2t\sqrt{(c\div h)}$ into its probability is $2\sqrt{(c\div\pi h)}\times te^{-t^2}dt$; and since $\int te^{-t^2}dt=\frac{1}{2}\int d.e^{-t^2}=\frac{1}{2}e^{-t^2}$, which from $t=0$ to $t=\infty$ becomes simply $\frac{1}{2}$, the integral of the above product from $t=0$ to $t=\infty$ is $\sqrt{(c\div\pi h)}$. Substituting for c its value (142) $=\frac{1}{2}\mu$, this result becomes $\sqrt{(\mu\div 2\pi h)}$; whence on computing $\sqrt{(1\div 2\pi)}$ we obtain

$$\text{mean error of series}=.398942\sqrt{(\mu\div h)}.$$

This is the mean error or mean risk in respect of positive errors alone, or on the supposition that negative errors are not taken into account. But as positive and negative errors are equally likely, the mean error in respect of negative errors is the same quantity, whence the mean error in respect of errors of both kinds is $.797884\sqrt{(\mu\div h)}$. This is usually called the *average* error. The mean error differs from the probable error in this respect, that it depends on the magnitude of individual errors, as well as on the proportion in which errors of different magnitudes occur. The probable error is independent of the magnitude.

148. When the quantity μ (the mean square of the errors) has been found from a series of observations, the precision, weight, probable error, and mean error, of a coming observation of the same kind are found by supposing $h=1$ in the above expressions, and are respectively

precision . .	$=\sqrt{(1\div 2\mu)}$
weight . .	$=1\div 2\mu$
probable error .	$=.674489\sqrt{\mu}$
mean error .	$=.398942\sqrt{\mu}$.

149. The preceding formulæ give the limits of the error to be feared in determining the value of a quantity from a series of observations, when the thing to be determined is that on which the observations are immediately made. We have now to apply the formulæ to the cases in which the quantity sought is not observed itself, but is a function of several others, which are separately determined by observation. The following problem is important:

Let u be a given function of a number of unknown quantitities, x, x', x'', &c.; it is required to assign the limits of the probable error in the determination of U, and the weight of the result, when values of x, x', x'', found from observations independent of each other, and respectively affected with the probable errors $\varrho\sqrt{\mu}$, $\varrho\sqrt{\mu'}$, $\varrho\sqrt{\mu''}$, &c. ($\varrho=$ .674489) are adopted instead of the true but unknown values of those quantities.

Let $u=f(x, x', x'',$ &c.) be the given function, λ, λ', λ'', &c. observed values of x, x', x'', &c. and make $\lambda-x=e$,

Probability. $\lambda'-x'=e'$, $\lambda''-x''=e''$, &c. so that e, e', e'', &c. are the errors of observation, supposed to be so small that their squares may be rejected. Make $\frac{du}{dx}=a$, $\frac{du}{dx'}=a'$, $\frac{du}{dx''}=a''$, &c., then a, a', a'', are given quantities; and on substituting $x+e$, $x'+e'$, $x''+e''$ for x, x', x'', respectively, in the equation $u=f(x, x', x'', \text{&c.})$, and supposing u to become $u+\mathrm{E}$ when the substitutions are made, so that E is the corresponding error of u, we have, on expanding u by Taylor's theorem,

$$\mathrm{E}=ae+a'e'+a'e''+\text{&c.}$$

in respect of a single observation of each of the quantities. Taking the square of both sides of the equation, we have

$$\mathrm{E}^2=a^2e^2+a'^2e'^2+a''^2e''^2+\text{&c.}+2aa'ee'+2aa''ee''+2a'a''e'e''+\text{&c.}$$

Now since positive and negative errors are supposed equally probable, the sums of the products ee', ee'', e', e'', &c. or their mean values, become each $=0$; therefore

$$\Sigma\mathrm{E}^2=a^2\Sigma e^2+a'^2\Sigma e'^2+a''\Sigma e''^2+\text{&c.}$$

Taking the mean value of each of these sums, and observing that μ the mean value of Σe^2 is independent of the number of observations (142), and assuming M to be the mean value of $\Sigma\mathrm{E}^2$, we get

$$\mathrm{M}=a^2\mu+a'^2\mu'+a''^2\mu''+\text{&c.}$$

This equation contains the solution of the problem, for all the functions of the error are given in terms of M. The probable error is $\cdot 674489\sqrt{\mathrm{M}}$.

150. Let W be the weight of the determination, and w, w', w'', &c. the weights corresponding to μ, μ', μ'', &c. then by the definition of weight, w is reciprocally proportioned to μ, and W to M; and we have by substitution,

$$\mathrm{W}=1\div\left(\frac{a^2}{w}+\frac{a'^2}{w'}+\frac{a''^2}{w''}+\text{&c.}\right)$$

If the weights are supposed all equal, this becomes

$$\mathrm{W}=\frac{w}{a^2+a'^2+a''^2+\text{&c.}}$$

Suppose the errors e, e' e'', &c. to be respectively multiplied by numbers proportional to the square roots of the weights, (which is equivalent to supposing all the observations to have the same degree of precision measured by $\sqrt{(\mu w)}$), then the value of M becomes

$$\mathrm{M}=a^2\mu w+a'^2\mu'w'+a''^2\mu''w''+\text{&c.}$$

But w being reciprocally as μ, we have $\mu w=\mu'w'=\mu''w''$, &c. $=1$, therefore

$$\mathrm{W}=\frac{1}{a^2+a'^2+a''^2+\text{&c.}}.$$

SECT. X. OF THE METHOD OF LEAST SQUARES.

151. In the determination of astronomical and physical elements from the data of observation, the thing which is actually observed is for the most part not the element which is sought to be determined, but a known function of that element. Thus, if V be a given function of X determined by the equation $\mathrm{V}=\mathrm{F}(\mathrm{X})$, the quantity observed may be a value of V, whilst the element sought to be determined is X. If the observation could give the value of V with absolute accuracy, then X would also be absolutely known; but as all observations are affected with certain errors of greater or less amount, owing to the imperfections of instruments or of sense, or the ever varying circumstances under which they are made, an exact value of X cannot be found from any single observation; and in order to obtain the utmost precision, it is necessary to employ a great number of observations, repeated under every variety of circumstance by which the result can be supposed to be affected.

Probability. 152. The observed quantity V, instead of being a function of a single element X, may be a function of several elements X, Y, Z, &c.; for example, V may be the position of a planet, in which case it is a function of the six elements of the orbit, for the determination of which the observation is made. Each observation gives rise to an equation of this form, $\mathrm{V}=\mathrm{F}(\mathrm{X}, \mathrm{Y}, \mathrm{Z}, \text{&c.})$; therefore when the number of equations is just equal to the number of unknown quantities, the problem is determinate; and supposing F to be an algebraic function, the values of X, Y, Z, &c. may be found by the ordinary methods of elimination. If the number of equations is less than the number of unknown quantities, the problem is indeterminate; but if greater, it may be said to be more than determinate, inasmuch as the equations may be combined in an infinite number of ways, each distinct combination giving a different value of the elements. It therefore becomes a question of the utmost importance to the perfection of the sciences of observation, to assign the particular combination which gives the most advantageous results, or values of X, Y, Z, &c. affected with the smallest probable errors.

153. As approximate values of the elements are in all cases either already known, or can be easily found, the object of accumulating observations is the correction of the approximate values. Let V be the true value of the thing observed, V_o an approximate value, however found, X the true value of the element sought, X_o an approximate value, corresponding to V_o, so that we have the two equations $\mathrm{V}=\mathrm{F}(\mathrm{X})$, $\mathrm{V}_o=\mathrm{F}(\mathrm{X}_o)$; also, let the observed value of V in any observation be L, and make

$$v=\mathrm{V}-\mathrm{L},\quad l=\mathrm{V}_o-\mathrm{L},$$

then v is the true but unknown error of the observation, and l its reputed error, that is to say, the difference between the computed value of the function and the result of the observation. Now if we assume x to represent the true correction of the approximate element, so that $\mathrm{X}=\mathrm{X}_o+x$, then, on substituting X_o+x for X in the function F, we get $\mathrm{V}=\mathrm{F}(\mathrm{X}_o+x)$; whence, expanding the function by Taylor's theorem, and rejecting terms multiplied by x^2 and higher powers of x, because x is a very small quantity

$$\mathrm{V}=\mathrm{V}_o+\frac{d\mathrm{V}_o}{d\mathrm{X}}x.$$

Let us now denote the differential coefficient, which is a known quantity, by a; then, observing that $\mathrm{V}-\mathrm{V}_o=v-l$, the equation becomes $v=l+ax$; that is to say, the true error of the observation is a linear function of the correction of the element.

154. In like manner, when there are several elements, X, Y, Z, &c.; on making $\frac{d\mathrm{V}_o}{d\mathrm{X}}=a$, $\frac{d\mathrm{V}_o}{d\mathrm{Y}}=b$, $\frac{d\mathrm{V}_o}{d\mathrm{Z}}=c$, &c. a single observation furnishes the equation

$$v=l+ax+by+cz+\text{&c.},$$

and a series of observations, whose errors are respectively v, v', v'', &c. gives a system of linear equations equal in number to the number of observations; namely,

$$\begin{aligned} v&=l+ax+by+cz+\text{&c.}\\ v'&=l'+a'x+b'y+c'z+\text{&c.}\\ v''&=l''+a''x+b''y+c''z+\text{&c.}\\ &\text{&c.} \end{aligned}\qquad (1)$$

and the object is to give such values to x, y, z, &c. that the errors v, v', v'', &c. in respect of the whole of the observations, shall be the least possible. The equations being supposed independent of each other, if their number is just equal to that of the unknown quantities, the errors v, v', v'', &c. can be made all zero; but if, as is usually the case, there are more equations than unknown quantities, it is impossible by any means whatever to annihilate the whole of them, and therefore all that can be accomplished is to

Probability. find the system of values of x, y, z, &c. which most nearly, and with the greatest probability, satisfies the whole of the equations. If the observations are not all equally good, the equations are supposed to be each multiplied by a number proportional to the square root of the presumed weight of the observation on which it depends, in order that they may all have the same degree of precision.

155. As the question is to find the most probable values of x, y, z, &c. the first thing necessary is to express each of these elements in terms of the observations. Suppose k, k', k'', &c. to be a system of indeterminate quantities, independent of x y, z, &c. and let the first of the above conditional equations be multiplied by k, the second by k', the third by k'', and so on; then adding the products, if k, k', k'', &c. be determined so as to make the coefficient of x equal to unit, and those of y, z, &c. each equal to 0; that is to say, so as to satisfy the equations

$$\begin{aligned} ka + k'a' + k''a'' + \&c. &= 1 \\ kb + k'b' + k''b'' + \&c. &= 0 \\ kc' + k'c' + k''c'' + \&c &= 0 \\ \&c. & \end{aligned} \qquad (2)$$

we shall then have $x = \mathrm{K} + kv + k'v' + k''v'' + \&c.$ where K is a quantity independent of v, v', v'', &c. Hence x is found $=\mathrm{K}$, with an error $= kv + k'v' + k''v'' + \&c.$; and the *weight* of the determination, by the formula in (150), is $\frac{1}{k^2 + k'^2 + k''^2 + \&c.}$. The weight of the determination is consequently greater in proportion as $k^2 + k'^2 + k''^2 + \&c.$ is smaller; and hence of all the possible systems of indeterminate coefficients, k, k', k'', &c. which satisfy the equations (1), the system which gives the most probable value of x, or the most advantageous result, is that for which $k^2 + k'^2 + k''^2 + \&c.$ is an absolute minimum.

156. We have now to find, in terms of known quantities, values of the indeterminate coefficients k, k', k'', &c. which satisfy the condition of the minimum. For the sake of abridging, let us denote the aggregate of the products $aa + a'a' + a''a'' + \&c$, by $\mathrm{S}(aa)$, that of $ab + a'b' + a''b'' + \&c.$ by $\mathrm{S}(ab)$, and so on, and also assume

$$\begin{aligned} \xi &= av + a'v' + a''v'' + \&c. \\ \eta &= bv + b'v' + b''v'' + \&c. \\ \zeta &= cv + c'v' + c''v'' + \&c. \end{aligned} \qquad (3)$$

On substituting in these equations the values of v, v', v'', &c. given by the equations (1), there results

$$\begin{aligned} \xi &= \mathrm{S}(al) + x\mathrm{S}(aa) + y\mathrm{S}(ab) + z\mathrm{S}(ac) + \&c. \\ \eta &= \mathrm{S}(bl) + x\mathrm{S}(ab) + y\mathrm{S}(bb) + z\mathrm{S}(bc) + \&c. \\ \zeta &= \mathrm{S}(cl) + x\mathrm{S}(ac) + y\mathrm{S}(bc) + z\mathrm{S}(cc) + \&c. \end{aligned} \qquad (4)$$

a system of equations equal in number to the number of elements x, y, z, &c. and from which, consequently, those elements would be determined absolutely if the observations were perfectly exact, that is, if the errrors v, v', v'', &c. were individually zero, and consequently ξ, η, ζ, &c., were each zero. On eliminating y, z, &c. from the last system, the value of x is given in terms of ξ, η, ζ, and known quantities by a linear equation of the following form:

$$x = \mathrm{A} + f\xi + g\eta + h\zeta + \&c. \qquad (5)$$

where f, g, h, &c. are co-efficients independent of x, y, z, &c. and also of ξ, η, ζ, &c.

If we now substitute in equation (5) the values ξ, η, ζ, &c. given by equations (3), and also assume

$$\begin{aligned} a &= fa + gb + hc + \&c. \\ a' &= f'a' + g'b' + h'c' + \&c. \\ a'' &= f''a'' + g''b'' + h''c'' + \&c., \end{aligned} \qquad (6)$$

we shall have by addition

$$x = \mathrm{A} + av + a'v' + a''v'' + \&c.;$$

whence it appears that a, a', a'', &c. are a system of multipliers by which y, z, &c. are eliminated from equations (1); they must therefore satisfy the equations (2), whence Probability.

$$\begin{aligned} aa + a'a' + a''a'' + \&c. &= 1 \\ ab + a'b' + a''b'' + \&c. &= 0 \\ ac + a'c' + a''c'' + \&c. &= 0. \end{aligned} \qquad (7)$$

Subtracting these from the equations (2) we obtain

$$\begin{aligned} 0 &= (k-a)a + (k'-a')a' + (k''-a'')a'' + \&c. \\ 0 &= (k-a)b + (k-a)b' + (k''-a'')b'' + \&c. \\ 0 &= (k-a)c + (k-a)c' + (k''-a'')c'' + \&c., \end{aligned}$$

on multiplying which respectively by f, g, h, and adding the products, we get by reason of the equations (6),

$$0 = (k-a)a + (k'-a')a' + (k''-a'')a'' + \&c.$$

This equation may be put under the form $k^2 + k'^2 + k''^2 + \&c.$

$$= a^2 + a'^2 + a''^2 + \&c. + (k-a)^2 + (k'-a')^2 + (k''-a'')^2 + \&c.$$

from which it is evident that $k^2 + k'^2 + k''^2 + \&c.$ will be a minimum when $k = a$, $k' = a'$, $k'' = a''$, &c. Hence it follows that the most probable value of x which can be deduced from the equations (1), is $x = \mathrm{A}$; and by (150) the weight of the determination is $1 \div (aa + a'a' + a''a'' + \&c.) = 1 \div \mathrm{S}(aa)$.

This quantity $\mathrm{S}(aa)$ is equal to f the co-efficient of ξ in the equation (5); for on multiplying the first of equations (7), by f, the second by g, and the third by h, and adding the products, we obtain by reason of equations (6),

$$aa + a'a' + a''a'' + \&c. = f.$$

157. The method explained in the two last paragraphs of determining the most advantageous combination of a system of linear equations, of the form of those in (154), is given by Gauss in his *Theoria Combinationis Observationum erroribus minimis obnoxiæ*, (Gottingen, 1823). The practical rule to which it leads is as follows: Having given a near value V of a function of several elements, X, Y, Z, &c. and also a series L, L′, L″, &c. of observed values of V, make $(\mathrm{V}-\mathrm{L})\sqrt{w} = v$, $(\mathrm{V}-\mathrm{L}')\sqrt{w'} = v'$, $(\mathrm{V}-\mathrm{L}'')\sqrt{w'}$, $= v''$, &c. and form the equations in (1). From these equations (4) are easily deduced; and from these, again, by elimination, are found the values of x, y, z, &c. the corrections of the approximate elements X, Y, Z, &c., in equations of the form (5), which, for the sake of symmetry, may be thus written:

$$\begin{aligned} x &= \mathrm{A} + (aa)\xi + (a\beta)\eta + (a\gamma)\zeta + \&c. \\ y &= \mathrm{B} + (a\beta)\xi + (\beta\beta)\eta + (\beta\gamma)\zeta + \&c. \\ z &= \mathrm{C} + (a\gamma)\xi + (\beta\gamma)\eta + (\gamma\gamma)\zeta + \&c. \end{aligned}$$

then the most probable values of x, y, z, &c. are repectively A, B, C, &c.; the weights of the determinations respectively $\frac{1}{(aa)}$, $\frac{1}{(\beta\beta)}$, $\frac{1}{(\gamma\gamma)}$, &c.; and the probable errors of the several determinations are $\rho\sqrt{(aa)}$, $\rho\sqrt{(\beta\beta)}$, $\rho\sqrt{(\gamma\gamma)}$, &c., where $\rho = \cdot 476936$.

158. The values of x, y, z, &c. now deduced are obtained immediately, by supposing the sum of the squares of the errors of observation to be a minimum. Thus, forming the squares of the equations (1), and making $\Omega = v^2 + v'^2 + v''^2 + \&c.$, the differentiation of Ω in respect of each of the variables x, y, z, &c. produces the quantities denoted in (156), by ξ, η, ζ, &c. that is to say, it gives

$$\frac{d\Omega}{dx} = 2\xi, \quad \frac{d\Omega}{dy} = 2\eta, \quad \frac{d\Omega}{dz} = 2\zeta, \ \&c.$$

therefore if Ω be a minimum, ξ, η, ζ, become severally zero, and the equations (4) give by elimination, $x = \mathrm{A}$, $y = \mathrm{B}$, $z = \mathrm{C}$, where A, B, and C denote the same quantities as above. Now from equation (5) the general value of x is

$$x = \mathrm{A} + (aa)\xi + (a\beta)\eta + (a\gamma)\zeta,$$

Probability. and the most probable value being $x=A$, it follows that the most probable values of the corrections x, y, z, are found by making the differential coefficients of Ω equal to zero, that is, by making $v^2+v'^2+v''^2+$ &c. an absolute minimum. Hence this method of combining equations of condition is called the *method of least squares;* and it follows from the preceding analysis, that it gives the most probable values of the corrections, or the most advantageous results.

159. As an example, let us suppose there is only one unknown element X, of which X_o is known to be an approximate value, and L, L′, L″, &c. are observed values, the weights of which are respectively proportional to w, w', w'', &c. and that it is required to determine the most probable value of X from the observations, and also the weight of the determination. Make $(X-L)\sqrt{w}=v$, $(X_o-L)\sqrt{w}=l$, and let x be the correction of X, so that $X=X_o-x$. On substituting this in $(X-L)\sqrt{w}=v$, we have $(X_o-x-L)\sqrt{w}=v$, or $v=l\sqrt{w}-x\sqrt{w}$. Each observation gives a similar equation, and the equations (1) in (154) consequently become

$$v=l\sqrt{w}-x\sqrt{w}$$
$$v'=l'\sqrt{w'}-x\sqrt{w'}$$
$$v''=l''\sqrt{w''}-x\sqrt{w''},\ \text{&c.}$$

therefore, multiplying each by the coefficient of its own x, we have $\xi=S(lw)-xS(w)$, whence consequently $x=S(lw)\div S(w)-\xi\div S(w)$, that is to say, the most probable value of x is

$$x=\frac{lw+l'w'+l''w''+\text{ &c.}}{w+w'+w''+\text{ &c.}},$$

and the weight of the determination is proportional to the reciprocal of $w+w'+w''+$ &c.

Since $X-L=x-l$, we have also

$$X=\frac{Lw+L'w+L''w+\text{ &c.}}{w+w'+w''+\text{ &c.}},$$

whence this proposition: If a series of values of an element are found from observations which have not all the same degree of precision, the most probable value of the element is found by multiplying each observation by a number proportional to its weight, and dividing the sum of the products by the sum of the weights; and the comparative weight of the result is unit divided by the sum of all the weights.

If the weights be all equal, and the number of the observations be h, then $X=(L+L'+L''+\text{ &c.})\div h$; that is to say, the average of a series of equally good observations gives the most probable value. The average may, therefore be considered as a particular case of the method of least squares.

160. To illustrate the method of proceeding when there are several elements to be corrected from the observations, we shall take the following numerical example from Gauss *(Theoria Motus)*. Suppose there are three elements, and that three observations, of equal weight, have given the equations $x-y+2z=3$, $3x+2y-5z=5$, $4x+y+4z=21$; and that a fourth observation, of which the relative weight is one-fourth, or its precision one-half, of that of the others has given $-2x+6y+6z=28$. The first step is to reduce this last equation to the same standard of weight with the others, for which purpose it must be multiplied by $\frac{1}{2}$; it then becomes $-x+3y+3z=14$. Now, as x, y, and z cannot be determined so as to satisfy four independent equations, we suppose each observation, or equation, to be affected with an error v, and accordingly obtain the following system of equations, corresponding to equations (1), viz.:

$$v=-3+x-y+2z$$
$$v'=-5+3x+2y-5z$$
$$v''=-21+4x+y+4z$$
$$v'''=-14-x+37+3z,$$

from which the most probable values of x, y, and z are to be deduced. Let each equation be multiplied by the coefficient of its own x, taken with its proper sign, namely, the first by 1, the second by 3, the third by 4, and the fourth by −1; the results added together give the value of ξ, namely, $\xi=-88+27x+6y$. In like manner, let the first be multiplied by −1, the second by 2, the third by 1, and the fourth by 3, the sum of the products will give η. Lastly, let the equations be multiplied respectively by the coefficients of z, and the sum of the products made equal to ζ; we have then the following equations corresponding to the equations (4)

$$\xi=-88+27x+6y+0$$
$$\eta=-70+6x+15y+z$$
$$\zeta=-107+0+y+54z.$$

From these we get by elimination

$$19899x=49154+809\xi-324\eta+6\zeta$$
$$737y=2617-12\xi+54\eta-\zeta$$
$$39798z=76242+12\xi-54\eta+1473\zeta,$$

whence (157) A, B, C, the most probable values of x, y, z, are respectively

$$A=\frac{49154}{19899}=2\cdot470,\ B=\frac{2617}{737}=3\cdot551,\ C=\frac{76242}{39798}=1\cdot916;$$

and the relative weights w, w', w'', are respectively

$$w=\frac{19899}{809}=24\cdot6,\ w'=\frac{737}{54}=13\cdot6,\ w''=\frac{39798}{1473}=27\cdot0,$$

whence the probable errors $(\cdot476936\div\sqrt{w})$ are respectively ·096, ·129, ·092.

The method of least squares, to which modern astronomy is indebted for much of its precision, was first proposed by Legendre, in his *Nouvelles Méthodes pour la Determination les Orbites des Comètes*, (Paris, 1806,) merely as means of avoiding inconvenience and uncertainty arising from the want of a uniform and determinate method of combining numerous equations of condition, and without reference to the theory of probability. The same method, however, had previously been discovered by Gauss, and a demonstration of it, deduced from the general theory of chances, was given by him in his *Theoria Motus*, (1809.) It may be shewn in various ways, that this method of combination gives values of the unknown quantities affected with the smallest probable errors; but it is to be observed, that all the demonstrations are subordinate to the hypothesis, that positive and negative errors of equal magnitude are equally probable, or that the average of a large number of results gives the most probable value, and consequently that the function which represents the probability of an error has the form assigned to it in (132).

The limits of this article will not permit us to enter into further details respecting the applications of the method of least squares. On the general theory of the probable errors of results deduced from observation, and the most advantageous methods of combining equations of condition, the reader may consult the *Théorie Analytique des Probabilités* of Laplace; the *Theoria Motus* of Gauss; the *Theoria Combinationis Observationum*, and the *Supplementum Theoriæ Combinationis*, &c. (Göttingen, 1828) of the same author; the *Recherches sur la Probabilité des Jugements*, with the two Memoirs of Poisson in the *Connaissance des Tems* for 1827 and 1832; and three masterly papers, by Mr. Ivory, in the *Philosophical Magazine* for 1825. In the volumes of the *Berliner Astronomisches Jahrbuch* for 1833, 1834, and 1835, M. Encke has treated the subject at great length, and given a number of formulæ calculated to facilitate the labours of the computer. We may also refer, in conclusion, to a very recent and remarkable disquisition on the theory of probable errors, by the celebrated astronomer Bessel, forming Nos. 358 and 359 of Schumacher's *Astronomische Abhandlungen*, Altona, October 1838.

(s.)

Probability TABLE of the Values of the Integral $\Theta = \frac{2}{\sqrt{\pi}}\int_0^\tau e^{-t^2}dt = 1 - \frac{2}{\sqrt{\pi}}\int_\tau^\infty e^{-t^2}dt$, for intervals each =·01, from $\tau=0$ to Probability $\tau=3$, with their first and second differences.

τ	Θ	Δ	Δ^2	τ	Θ	Δ	Δ^2	τ	Θ	Δ	Δ^2	τ	Θ	Δ	Δ^2
0·00	0·0000000	112833	22	0·75	0·7111556	63811	962	1·50	0·9661052	11716	349	2·25	0·9985373	698	30
0·01	·0112833	112811	45	0·76	·7175367	62849	961	1·51	·9672768	11367	340	2 26	·9986071	668	30
0·02	·0225644	112766	67	0·77	·7238216	61888	957	1·52	·9684135	11027	332	2·27	·9986739	638	29
0·03	·8338410	112699	90	0·78	·7300104	60931	956	1·53	·9695162	10695	325	2·28	·9987377	609	27
0·04	·0451109	112609	112	0·79	·7361035	59975	952	1·54	·9705857	10370	316	2·29	·9987986	582	26
0·05	·0563718	112497	135	0·80	·7421010	59023	948	1·55	·9716227	10054	309	2·30	·9988568	556	25
0·06	·0676215	112362	158	0·81	·7480033	58075	945	1·56	·9726281	9745	301	2·31	·9989124	531	24
0·07	·0788577	112204	179	0·82	·7538108	57130	941	1·57	·9736026	9444	294	2·32	·9989655	507	23
0·08	·0900781	112025	201	0·83	·7595238	56189	936	1·58	·9745470	9150	286	2·33	·9990162	484	23
0·09	·1012806	111824	224	0·84	·7651427	55253	931	1·59	·9754620	8864	279	2·34	·9990646	461	20
0·10	·1124630	111600	246	0·85	·7706680	54322	926	1·60	·9763484	8585	273	2 35	·9991107	441	21
0·11	·1236230	111354	267	0·86	·7761002	53396	921	1·61	·9772069	8312	264	2·36	·9991548	420	19
0·12	·1347584	111087	288	0·87	·7814398	52475	916	1·62	·9780381	8048	259	2·37	·9991968	401	19
0·13	·1458671	110799	310	0·88	·7866873	51559	909	1·63	·9788429	7789	251	2·38	·9992369	382	18
0·14	·1569470	110489	331	0·89	·7918432	50650	904	1·64	·9796218	7538	245	2·39	·9992751	364	17
0·15	·1679959	110158	352	0·90	·7969082	49746	897	1·65	·9803756	7293	238	2·40	·9993115	347	16
0·16	·1790117	109806	372	0·91	·8018828	48849	891	1·66	·9811049	7055	231	2·41	·9993462	331	16
0·17	·1899923	109434	393	0·92	·8067677	47958	883	1·67	·9818104	6824	226	2·42	·9993793	315	15
0·18	·2009357	109041	414	0·93	·8115635	47075	877	1·68	·9824928	6598	220	2·43	·9994108	300	14
0·19	·2118398	108627	434	0·94	·8162710	46198	870	1·69	·9831526	6378	212	2·44	·9994408	286	14
0·20	·2227025	108193	453	0·95	·8208908	45328	861	1·70	·9837904	6166	208	2·45	·9994694	272	12
0·21	·2335218	107740	473	0·96	·8254236	44467	855	1·71	·9844070	5958	201	2·46	·9994966	260	14
0·22	·2442958	107267	492	0·97	·8298703	43612	846	1·72	·9850028	5757	196	2·47	·9995226	246	11
0·23	·2550225	106775	512	0·98	·8342315	42766	839	1·73	·9855785	5561	190	2·48	·9995472	235	12
0·24	·2657000	106263	529	0·99	·8385081	41927	830	1·74	·9861346	5371	185	2·49	·9995707	223	10
0·25	·2763263	105734	549	1·00	·8427008	41097	822	1·75	·9866717	5186	179	2·50	·9995930	213	11
0·26	·2868997	105185	567	1·01	·8468105	40275	813	1·76	·9871903	5007	175	2·51	·9996143	202	10
0·27	·2974182	104618	584	1·02	·8508380	39462	805	1·77	·9876910	4832	168	2·52	·9996345	192	9
0·28	·3078800	104034	601	1·03	·8547842	38657	796	1·78	·9881742	4664	165	2·53	·9996537	183	10
0·29	·3182834	103433	619	1·04	·8586499	37861	786	1·79	·9881406	4499	159	2·54	·9996720	173	8
0·30	·3286267	102814	636	1·05	·8624360	37075	777	1·80	·9890905	4340	154	2·55	·9996893	165	8
0 31	·3389081	102178	652	1·06	·8661435	36297	768	1·81	·9895245	4186	150	2·56	·9997058	157	8
0·32	·3491259	101526	667	1·07	·8697732	35529	760	1·82	·9899431	4036	144	2·57	·9997215	149	8
0·33	·3592785	100859	684	1·08	·8733261	34769	749	1·83	·9903467	3892	141	2·58	·9997364	141	6
0·34	·3693644	100175	698	1·09	·8768030	34020	740	1·84	·9907359	3751	136	2·59	·9997505	135	8
0·35	·3793819	99477	714	1·10	·8802050	33280	731	1·85	·9911110	3615	133	2·60	·9997640	127	6
0·36	·3893296	98763	729	1·11	·8835330	32549	721	1·86	·9914725	3482	127	2·61	·9997767	121	6
0·37	·3992059	98034	742	1·12	·8867879	31828	712	1·87	·9918207	3355	124	2·62	·9997888	115	6
0·38	·4090093	97292	755	1·13	·8899707	31116	701	1·88	·9921562	3231	120	2·63	·9998003	109	6
0·39	·4187385	96537	769	1·14	·8930823	30415	691	1·89	·9924793	3111	116	2·64	·9998112	103	5
0·40	·4283922	95768	782	1·15	·8961238	29724	682	1·90	·9927904	2995	112	2·65	·9998215	98	5
0·41	·4379690	94986	795	1·16	·8990962	29042	672	1·91	·9930899	2883	108	2·66	·9998313	93	5
0·42	·4474676	94191	807	1·17	·9020004	28370	661	1·92	·9933782	2775	106	2·67	·9998406	88	4
0·43	·4568867	93384	817	1·18	·9048374	27709	652	1·93	·9936557	2669	101	2·68	·9998494	84	5
0·44	·4662251	92567	830	1·19	·9076083	27057	642	1·94	·9939226	2568	99	2·69	·9998578	79	4
0·45	·4754818	91737	840	1·20	·9103140	26415	631	1·95	·9941794	2469	95	2·70	·9998657	75	4
0·46	·4846555	90897	853	1·21	·9129555	25784	622	1 96	·9944263	2374	91	2·71	·9998732	71	4
0·47	·4937452	90046	861	1·22	·9155339	25162	611	1·97	·9946637	2283	89	2·72	·9998803	67	4
0·48	·5027498	89185	869	1·23	·9180501	24551	602	1·98	·9948920	2194	85	2·73	·9998870	63	2
0·49	·5116683	88316	878	1·24	·9205052	23949	591	1·99	·9951114	2109	84	2.74	·9998933	61	4
0·50	·5204999	87438	888	1·25	·9229001	23358	581	2·00	·9953223	2025	78	2·75	·9998994	57	3
0·51	·5292437	86550	896	1·26	·9252359	22777	571	2·01	·9955248	1947	79	2·76	·9999051	54	3
0·52	·5378987	85654	903	1·27	·9275136	22206	561	2·02	·9957195	1868	73	2·77	·9999105	51	3
0·53	·5464641	84751	910	1·28	·9297342	21645	552	2·03	·9959063	1795	72	2·78	·9999156	48	2
0·54	·5549392	83841	917	1·29	·9318987	21093	541	2·04	·9960858	1723	69	2·79	·9999204	46	3
0·55	·5633233	82924	923	1·30	·9340080	20552	532	2·05	·9962581	1654	67	2·80	·9999250	43	2
0·56	·5716157	82001	930	1·31	·9360632	20020	522	2·06	·9964235	1587	65	2·81	·9999293	41	3
0·57	·5798158	81071	935	1 32	·9380652	19498	511	2·07	·9965822	1522	61	2·82	·9999334	38	1
0·58	·5879229	80136	940	1·33	·9400150	18987	502	2·08	·9967344	1461	61	2·83	·9999372	37	3
0·59	·5959365	79196	945	1·34	·9419137	18485	493	2·09	·9968805	1400	57	2·84	·9999409	34	1
0·60	·6038561	78251	949	1·35	·9437622	17992	482	2·10	·9970205	1343	55	2·85	·9999443	33	2
0·61	·6116812	77302	953	1·36	·9455614	17510	474	2·11	·9971548	1288	54	2·86	·9999476	31	2
0·62	·6194114	76349	955	1·37	·9473124	17036	463	2·12	·9972836	1234	51	2·87	·9999507	29	2
0·63	·6270463	75394	959	1·38	·9490160	16573	455	2·13	·9974070	1183	50	2·88	·9999536	27	1
0·64	·6345857	74435	962	1·39	·9506733	16118	445	2 14	·9975253	1133	47	2 89	·9999563	26	2
0·65	·6420292	73473	963	1·40	·9522851	15673	435	2·15	·9976386	1086	47	2·90	·9999589	24	1
0·66	·6493765	72510	965	1·41	·9538524	15238	427	2·16	·9977472	1039	45	2·91	·9999613	23	1
0·67	·6566275	71545	966	1·42	·9553762	14811	418	2·17	·9978511	994	40	2·92	·9999636	22	1
0·68	·6637820	70579	968	1·43	·9568573	14393	409	2·18	·9979505	954	41	2·93	·9999658	21	2
0·69	·6708399	69611	967	1·44	·9582966	13984	399	2·19	·9980459	913	41	2·94	·9999679	19	1
0·70	·6778010	68644	968	1·45	·9596950	13585	391	2·20	·9981372	872	37	2·95	·9999698	18	1
0·71	·6846654	67676	968	1·46	·9610535	13194	382	2·21	·9982244	835	36	2·96	·9999716	17	...
0.72	·6914330	66708	966	1·47	·9623729	12812	374	2.22	·9983079	799	35	2·97	·9999733	...	...
0·73	·6981038	65742	966	1·48	·9636541	12438	365	2·23	·9983878	764	33			...	...
0·74	·7046780	64776	965	1·49	·9648979	12073	357	2·24	·9984642	731	33	3·00	·9999779	...	...

PROBATE of a will or testament, in *Law*, is the exhibiting and proving of last wills and testaments before the ecclesiastical judge delegated by the bishop, who is ordinary of the place where the party died.

PROBATION, in the universities, is the examination and trial of a student who is about to take his degrees.

PROBATIONER, in the Church of Scotland, a student in divinity, who, upon bringing certain certificates and testimonials, is admitted to undergo several trials; and, on his acquitting himself properly in these, is provided with a license to preach.

PROBLEM, in *Logic*, is a proposition that appears neither absolutely true nor absolutely false; and, consequently, may be asserted either in the affirmative or negative.

PROBLEM, in *Geometry*, is a proposition, in which some operation or construction is required; as to divide a line or angle, erect or let fall perpendiculars.

PROBOLINGO, the capital of a district of Java, occupied by a native of China, who purchased it from the former government. He was called the China Major, and on the 18th of June 1813, was unfortunately murdered along with two British officers, Colonel Fraser of the 78th Regiment, and Captain Macpherson, who, on their way to disperse a band of insurgents, fell into an ambuscade.

PROBY'S ISLAND, a small island in the South Pacific Ocean, so called by Captain Edwards in 1791. The natives call it Onoo-afou. Long. 175. 51. W. Lat. 15. 53. S.

PROCESS, in *Law*, denotes the proceedings in any cause, real or personal, civil or criminal, from the original writ to the conclusion of the suit.

PROCESS, in *Chemistry*, the whole course of an experiment or series of operations, tending to produce something new.

PROCESS, in *Anatomy*, denotes any protuberance or eminence in a bone.

PROCESSION, a ceremony in the Catholic church, consisting of a formal march of the clergy and people, putting up prayers, and in this manner visiting some church, or other holy place.

PROCLAMATION, a public notice given of any thing of which the king thinks proper to advertise his subjects.

Proclamations form a branch of the king's prerogative, and they have a binding force, when they are grounded upon and enforce the laws of the realm. For though the making of laws is entirely the work of a distinct part, the legislative branch of the sovereign power, yet the manner, time, and circumstances of putting those laws in execution, must frequently be left to the discretion of the executive magistrate; and therefore his constitutions or edicts, concerning those points, which we call *Proclamations*, are binding upon the subject, where they do not either contradict the old laws, or tend to establish new ones, but only enforce the execution of such laws as are already in being, in such manner as the king shall judge necessary.

PROCLUS, surnamed DIADOCUS, a Greek philosopher and mathematician, was born in Lycia, and lived about the year 500. He was the disciple of Syrianus, and the friend of the Emperor Anastasius. It is said, that when Vitalian laid siege to Constantinople, Proclus burned his ships with large brazen specula. This philosopher was a Pagan, and wrote against the Christian religion. There are still extant his Commentaries on some of Plato's books, and other of his works, written in Greek.

PROCONSUL, a Roman magistrate, sent to govern a province with consular authority.

The proconsuls were appointed out of the body of the senate; and commonly, when the year of any one's consulate expired, he was sent as proconsul into some province. The proconsuls decided cases of equity and justice, either privately in their palace, where they received petitions, heard complaints, and granted writs under their seal; or publicly, in the common hall, with the usual formalities observed in the court of judicature at Rome. Their office lasted only a year.

PROCOPIUS, a Greek historian, born in Cæsarea. He acquired great reputation by his works in the reign of Justinian, and was secretary to Belisarius during all the wars carried on by that general in Persia, Africa, and Italy. Having at length became senator, he obtained the title of *illustrious*, and was made prætor of Constantinople.

PROCTOR, a person commissioned to manage another person's cause in any court of the civil or ecclesiastical law.

PROCTOR, in the English universities. See UNIVERSITIES.

PROCURATION, an act or instrument by which one person is empowered to treat, transact, or receive, in the name of another.

PROCYON, in *Astronomy*, a fixed star of the second magnitude, situated in canis minor, or the little dog.

PRODICUS, a celebrated sophist, was a native of Julis in the island of Ceos, and flourished about B.C. 432. He was the contemporary of Democritus of Abdera, and Gorgias of Leontium, and he was the disciple of Protagoras, whom he rivalled in eloquence. His talents were so highly appreciated by his fellow-citizens, that he was employed on various embassies, and on his arrival at Athens, he opened a school where he was attended by the most distinguished men of the age, Euripides, Socrates, Theramenes, and Isocrates. Xenophon has preserved an apologue of Prodicus, which is considered as one of the most precious fragments of antiquity: it is Hercules between virtue and vice. In the Axiochus of Plato there is also the analysis of a harangue which Prodicus composed to dissipate all fears of death. He was at last accused of being a corrupter of youth, and condemned to drink the fatal bowl of hemlock.

PRODUCT, in *Arithmetic* and *Geometry*, the factum of two or more numbers, or lines, into one another. Thus $5 \times 4 = 20$, the product required.

PROEDRI, amongst the Athenians, were magistrates, who had the first seats in the public assemblies, and whose office it was to propose at each assembly the things to be deliberated on and determined. Their office always ended with the meeting.

PROFESSOR, in the universities, a person who teaches or reads public lectures in some art or science. See UNIVERSITIES.

PROFILE, in *Architecture*, the draught of a building, fortification, or other structure, in which are expressed the several heights, widths, and thicknesses, such as they would appear were the building cut down perpendicularly from the roof to the foundation.

Profile, in this sense, amounts to the same with *elevation*, and stands opposed to *plan* or *ichnography*.

PROFILE is also used for the contour or outline of a figure, building, member of architecture, or the like; as a base, a cornice, and the like. Hence *profiling* is sometimes used for designing, or describing the member with rule, compass, and other instruments.

PROFILE, in *Sculpture* and *Painting*. A head, or a portrait, is said to be in *profile*, when either is represented sidewise, or in a side-view; as, when in a portrait there is but one side of the face, one eye, one cheek, &c. shown, and nothing of the other. On almost all medals, the faces are represented in *profile*.

PROGRAMMA, anciently signified a letter sealed with the king's seal. Programma is also an university term for a billet issued by way of invitation to an oration, and containing the argument, or as much of it as is necessary for understanding the same.

PROGRESSION, in general, denotes a regular advancing, or going forwards, in the same course or manner.

PROGRESSION, in *Mathematics*, is either arithmetical or geometrical. Continued arithmetical proportion is, where the terms increase and decrease by equal differences, and is called *arithmetical progression*. *Geometrical progression* is when the terms increase or decrease by equal ratios.

PROJECTILES.

Projectiles. THE term *Projectiles* is applied to that part of mechanical philosophy which treats of the motion of bodies anyhow projected from the surface of the earth, and influenced by the action of terrestrial gravity.

It is demonstrated in the physical part of astronomy, that a body so projected must describe a conic section, having the centre of the earth in one focus; and that it will describe round that focus areas proportional to the times. It follows also from the principles of that science, that if the velocity of projection exceed 36,700 feet in a second, the body (if not resisted by the air) would describe a hyperbola; if the velocity be just 36,700 feet in a second, the body would describe a parabola; and a body projected with a smaller velocity than this would describe an ellipse. In the first case, if projected directly upwards, it would never return, but proceed for ever, its velocity continually diminishing, but never becoming less than an assignable portion of the excess of the initial velocity above 36,700 feet in a second. In the second case it would never return; its velocity would diminish without end, but never be extinguished. In the third case it would proceed till its velocity was reduced to an assignable portion of the difference between 36,700 feet and its initial velocity, and would then return, regaining its velocity by the same degrees and in the same places as it lost it. These are necessary consequences of a gravity directed to the centre of the earth, and inversely proportional to the square of the distance. But in the greatest projections that we are able to make, the gravitations are so nearly equal, and in directions so nearly parallel, that it would be ridiculous affectation to pay any regard to the deviations from equality and parallelism. A bullet rising a mile above the surface of the earth loses only $\frac{1}{2000}$ of its weight, and a horizontal range of 4 miles makes only 4′ of deviation from parallelism.

Let us therefore assume gravitation as equal and parallel. The errors arising from this assumption are quite insensible in all the uses which can be made of this theory.

Gravity must be considered by us as a constant or uniform accelerating or retarding force, according as it produces the descent, or retards the ascent, of a body. A constant or invariable accelerating force is one which produces an uniform acceleration; that is, which in equal times produces equal increments of velocity, and therefore produces increments of velocity proportional to the times in which they are produced. Forces are of themselves imperceptible, and are only sensible in their effects; and they have no measure but the effect, or what *measures* the effect; and every thing which we can discover with regard to those measures, we may affirm with regard to the things of which we assume them as the measures. Hence this proposition:—

The motion of a falling body, or of a body projected directly downwards, is uniformly accelerated; and that of a body projected directly upwards is uniformly retarded; that is, the acquired velocities are as the times in which they are acquired by falling, and the extinguished velocities are as the times in which they are extinguished. The following consequences are readily deduced from the proposition now enunciated:

1. If bodies simply fall, not being projected downwards by an external force, the times of the falls are proportional to the final velocities; and the times of ascents, which terminate by the action of gravity alone, are proportional to the initial velocities.

2. The spaces described by a heavy body falling from rest are as the squares of the acquired velocities; and the differences of these spaces are as the differences of the squares of the acquired velocities; and, on the other hand, the heights to which bodies projected upwards will rise, before their motions are extinguished, are as the squares of the initial velocities.

3. The spaces described by falling bodies are proportional to the squares of the times from the beginning of the fall; and the spaces described by bodies projected directly upwards are as the squares of the times of the ascents.

4. The space described by a body falling from rest is one-half of the space which the body would have uniformly described in the same time, with the velocity acquired by the fall. And the height to which a body will rise, in opposition to the action of gravity, is one-half of the space which it would uniformly describe in the same time with the initial velocity.

In like manner, the difference of the spaces which a falling or rising body describes in any equal successive parts of its fall or rise, is one-half of the space which it would uniformly describe in the same time with the difference of the initial and final velocities.

The last proposition will be more conveniently expressed for our purpose as follows:

A body moving uniformly during the time of any fall with the velocity acquired thereby, will in that time describe a space double of that fall; and a body projected directly upwards will rise to a height which is one-half of the space which it would describe in the time of its ascent with the initial velocity of projection, if the motion continued uniform.

It is a matter of observation and experience, that a heavy body falls 16 feet and one inch English measure in a second of time; and therefore acquires the velocity of 32 feet 2 inches per second. This cannot be ascertained directly, with the precision that is necessary. A second is too small a portion of time to be exactly measured and compared with the space described; but the observation is made with the greatest accuracy by comparing the motion of a falling body with that of a pendulum. The time of a vibration is to the time of falling through half the length of the pendulum, as the circumference of a circle is to its diameter. The length of a pendulum can be ascertained with great precision; and in this way the space fallen through in a second has been accurately measured.

As all forces are ascertained by the accelerations which they produce, they are conveniently measured by comparing their accelerations with the acceleration of gravity. This therefore has been assumed by all the later and best writers on mechanical philosophy as the unit by which every other force is measured. It gives us a perfectly distinct notion of the force which retains the moon in its orbit, when we say it is the 3600th part of the weight of the moon at the surface of the earth. We mean by this, that if a bullet were weighed at the surface of the earth by a spring steelyard, and pulled the spring out to the mark 3600; if the body were then taken to the distance of the moon, it would pull the spring out only to the mark 1. And we make this assertion on the authority of our having observed that a body at the distance of the moon falls from that distance $\frac{1}{3600}$th part of 16 feet in a second. We do not therefore compare the *forces*, which are imperceptible things; we compare the accelerations, which are at the same time their effects and their measures.

Projectiles. Philosophers have therefore been at great pains to determine with precision the fall of heavy bodies, in order to have an exact measure of the accelerating power of terrestrial gravity. Now we must here observe, that this measure may be taken in two ways; we may take the space through which the heavy body falls in a second; or we may take the velocity which it acquires in consequence of gravity having acted on it during a second. The last is the proper measure, for it is the immediate effect on the body. The action of gravity has changed the state of the body by giving it a determination to motion downwards; and this both points out the nature, and the degree or intensity, of the force of gravity. The space described in a second by falling, is not an invariable measure; for, in the successive seconds, the body falls through 16, 48, 80, 112, &c. feet, but the changes of the body's state in each second is the same. At the beginning it had no determination to move with any appreciable velocity; at the end of the first second it had a determination by which it would have gone on for ever (had no subsequent force acted on it) at the rate of 32 feet per second. At the end of the next second, it had a determination by which it would have moved for ever, at the rate of 64 feet per second. At the end of the third second, it had a determination by which it would have moved for ever, at the rate of 96 feet per second, &c. The differences of these determinations are constant, and amount to 32 feet per second. This is therefore the indication and proper measure of the constant or invariable force of gravity. The space fallen through in the first second is of use only as it is one-half of the measure of this determination; and as halves have the proportion of their wholes, different accelerating forces may be safely affirmed to be in the proportion of the spaces through which they uniformly impel bodies in the same time. But we should always recollect, that this is but one-half of the true measure of the accelerating force.

We now proceed to investigate the formulæ of rectilinear motion.

Let x be the space described by a moving body in a certain time t, and v the velocity acquired at the end of the time t. When the motion is uniform, the space described is in the compound ratio of the velocity and the time, therefore $x=vt$. In the case of accelerated or retarded motion, the velocity varies by infinitely small degrees, and we may therefore assume it to be uniform during an infinitely small portion of time dt. But the space over which the body moves in the time dt, with the uniform velocity v, is vdt; therefore the increment of the space in the time dt being dx, we have $dx=vdt$, whence $v=\frac{dx}{dt}$.

Let φ = the force which accelerates or retards the moving body at the end of the time t. The force φ is supposed to act in the straight line in which the body is moving at the instant; and as an accelerating force becomes a retarding force by changing the sign from positive to negative, it is usually called, in both cases, the *accelerating force*. In order to obtain the measure of φ, we must consider the effect it produces. Since the motion may be regarded as uniform during an infinitely small portion of time dt, if v be the velocity at the end of the time t, then $v+dv$ will be the velocity at the end of the time $t+dt$, so that dv is the augmentation of velocity produced by the accelerating force φ in the time dt. Assume F to be a constant force, which produces a velocity = V in the portion of time which is taken as unit; then the velocity produced by the force F in the time dt is Vdt, and we have this proportion,

$$\varphi : F :: dv : Vdt,$$

the forces being measured by the velocities which they communicate to a given body in the same time. Now, suppose F to be the unit of force, and V the unit of velocity, the proportion becomes $\varphi : 1 :: dv : dt$, whence $\varphi=\frac{dv}{dt}$. Projectiles.

On differentiating the equation $v=\frac{dx}{dt}$, we get $\frac{dv}{dt}=\frac{d^2x}{dt^2}$, whence $\varphi=\frac{d^2x}{dt^2}$. The relations between the velocity, the space described, the time, and the accelerating force, are consequently given by the three following equations, of which the last is a consequence of the other two, viz.

$$v=\frac{dx}{dt},\quad \varphi=\frac{dv}{dt},\quad \varphi=\frac{d^2x}{dt^2}. \qquad (1)$$

Suppose the accelerating force to be terrestrial gravity, and let it be denoted by g. We have then, from the third of the above equations $\frac{d^2x}{dt^2}=g$; the integral of which is $\frac{dx}{dt}=gt$, or $v=gt$ (which requires no correction, since v and t vanish together). We have also $dx=gtdt$; whence by a second integration $x=\frac{1}{2}gt^2$, which is also the complete integral, since x and t vanish together. This last equation gives $2gx=g^2t^2=v^2$; whence $v=\sqrt{(2gh)}$. We have therefore the following expressions for the velocity, the time, and the space described, or height from which a body must fall *in vacuo* to acquire a given velocity, and which we shall denote by h, viz.

$$\text{I. } v=gt=\sqrt{(2gh)},$$

$$\text{II. } t=\frac{v}{g}=\sqrt{\frac{2h}{g}},$$

$$\text{III. } h=\frac{v^2}{2g}=\tfrac{1}{2}gt^2.$$

It is found by experiment that the height through which a heavy body descends by the force of gravity in a vacuum, in a second of time, is $16\frac{1}{12}$ English feet. For convenience, we shall call this 16 feet. Assuming, therefore, one second as the unit of time, the last equation gives $g=2h=32$ feet; and the three equations become, in respect of any time t, and height h,

$$\text{I. } v=32t=\sqrt{(64h)}=8\sqrt{h},$$

$$\text{II. } t=\frac{v}{32}=\tfrac{1}{4}\sqrt{h},$$

$$\text{III. } h=\frac{v^2}{64}=16t^2.$$

To give some examples of the use of these formulæ, let it be required,

1. To find the time of falling through 256 feet. Here $h=256$, $\sqrt{256}=16$, and $16\div4=4$. Therefore $t=4$ seconds.

2. To find the velocity acquired by falling four seconds. Here $t=4$, $32\times4=128$ feet per second.

3. To find the velocity acquired by falling 625 feet. Here $h=625$, $\sqrt{h}=25$, $8\sqrt{h}=200$ feet per second,

4. To find the height to which a body will rise when projected with the velocity of 56 feet per second, or the height through which a body must fall to acquire this velocity. In this case we have

$$v=56,\ 56\div8=7,\ =\sqrt{h},\ 7^2=h,\ =49 \text{ feet.}$$

[or $56^2=3136$, $3136\div64=49$ feet.

5. Suppose a body projected directly downwards with the velocity of 10 feet per second; what will be its velocity after four seconds? In four seconds it will have acquired, by the action of gravity, the velocity of 4×32, or 128 feet, and therefore its whole velocity will be 138 feet per second.

6. To find how far it will have moved, compound its mo-

Projectiles.

tion of projection, which will be 40 feet in four seconds, with the motion which gravity alone would have given it in that time, which is 256 feet; and the whole motion will be 296 feet.

7. Suppose the body projected, as in the 5th example, and that it is required to determine the time it will take to pass through 296 feet, and the velocity it will have acquired.

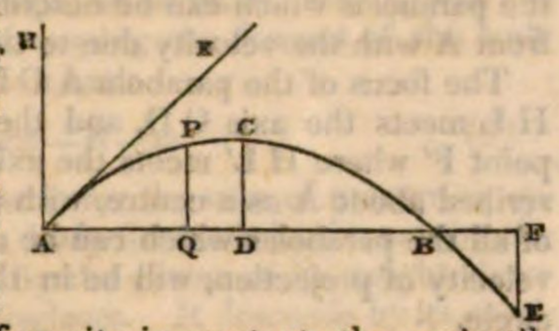
Find the height h, through which it must fall to acquire the velocity of projection, 10 feet, and the time t of falling from this height. Then find the time t' of falling through the height $296+h$, and the velocity v acquired by this fall. The time of describing the 296 feet will be $t'-t$, and v is the velocity required.

These examples will suffice for the perpendicular ascents or descents of heavy bodies, abstracting from the resistance of the air. We now proceed to consider the motions of bodies projected obliquely. The subject is one of considerable interest, as it forms the foundation of the theory of gunnery.

Let a body be projected from the point A (fig. 1.) in any direction AK not perpendicular to the horizon, and with a given velocity $=a$; it is required to determine the path of the body, and all the circumstances of its motion.

Since gravity acts only in the vertical direction, and the body, after being projected, is acted on by no other accelerating force, it is evident, in the first place, that the whole of the trajectory, or path described by the projectile, must be contained in the vertical plane which passes through AK. In the second place, since the action of gravity is constant, the projectile must describe a continuous curve, to which AK is a tangent at A. Through A draw AB horizontal, and AH vertical, and let these lines be taken as the axes of the rectangular co-ordinates to which the different points of the curve are referred. Let P be the place of the projectile at the end of the time t; draw PQ perpendicular to AB, and make AQ$=x$, PQ$=y$. The object is now to find the equation of the trajectory by establishing a relation between the co-ordinates x and y.

Fig. 1.



Let the angle KAB, which the initial direction of the projectile makes with the horizon, be denoted by A. As we abstract from the resistance of the air, the motion in the direction AK is uniform, and proportional to the time t; and the velocity of projection being a, the velocity in the direction AB (which is not affected by gravity) is also uniform, and equal to $a\cos A$, therefore the space passed over being equal to the product of the time by the velocity, we have $x=a\cos A$. To find y, we must consider that the motion in the vertical direction is made up of two parts; first, that which is due to the velocity of projection; and, second, that which arises from the action of gravity. The velocity in the direction AH, independent of gravity, is $a\sin A$; and therefore the space described in that direction in the time t, is $ta\sin A$. But by the formula III. the space through which the body is carried in the time t by the accelerating force of gravity is $\frac{1}{2}gt^2$; and as this is in the direction opposite to the former, it must be taken with the negative sign. We have therefore $y=ta\sin A-\frac{1}{2}gt^2$. The values of x and y are thus given in terms of the time; and on eliminating t between the two equations, viz.

$$x=ta\cos A, \qquad y=ta\sin A-\tfrac{1}{2}gt^2, \qquad (2)$$

we shall have the equation of the trajectory. The first gives $t=x\div a\cos A$, on substituting which in the second, there results

$$y=x\tan A-\tfrac{1}{2}g\frac{x^2}{a^2\cos^2 A},$$

which is an equation to the Apollonian parabola, having its axis parallel to the ordinates y, and its parameter equal to $\frac{1}{2}g\div a^2\cos^2 A$.

By the formula I. we have $a=\sqrt{(2gh)}$, therefore $a^2=2gh$; and on substituting this value of a^2, the equation becomes

$$y=x\tan A-\frac{x^2}{4h\cos^2 A}. \qquad (3)$$

Having found the equation of the curve, it is easy to assign its position in the plane of the co-ordinates. Let B be the point in which the parabola meets the horizontal line drawn through A, C the vertex of the parabola, and let CD be perpendicular to AB. The point C is thus found. Let θ be the angle which the tangent to the curve at any point P makes with the axis AB; we have then for any curve whatever, $\tan\theta\, dx=dy$. At the vertex, the tangent becomes parallel to AB, consequently θ vanishes, and we have $\frac{dy}{dx}=0$

Now on differentiating the equation (2), we find

$$\frac{dy}{dx}=\tan A-\frac{x}{2h\cos^2 A};$$

therefore at the vertex, $0=\tan A-\frac{x}{2h\cos^2 A}$, whence

$x=2h\cos A\sin A$. Substituting this value of x in equation (3), we get, after reduction, $y=h\sin^2 A$. Hence denoting the co-ordinates of the vertex by x_1 and y_1 that is, making AD$=x_1$, DC$=y_1$, we have the two equations to determine x_1 and y_1, namely

$$x_1=2h\cos A\sin A, \qquad y_1=h\sin^2 A. \qquad (4)$$

To find the point B in which the projectile meets the horizontal line AB, it is only necessary to make $y=0$ in equation (3). This gives $0=x\tan A-\frac{x^2}{4h\cos^2 A}$; whence $4h\cos^2 A\tan A=x$, and therefore

$$x=\text{AB}=4h\cos A\sin A=2h\sin 2A. \qquad (5)$$

From this equation it appears that when the velocity of projection a, or the height h, corresponding to that velocity, is given, the line AB, which is called the *amplitude* or *horizontal range*, is a maximum when the angle of elevation A (that is, KAB) is equal to 45°, for then $\sin 2A=1$. In this case we have AB$=2h$, that is to say, when a ball is projected with an angle of elevation equal to 45 degrees, the amplitude or range on the horizontal plane is equal to twice the height from which a body must fall in order to acquire a velocity equal to the velocity of projection.

To find the velocity at any point P of the trajectory, in the direction of the tangent at that point, let z denote the arc AP, then, the velocity being equal to the increment of the space passed over, divided by the increment of the time, we have $v=\frac{dz}{dt}$, whence $v^2=\frac{dx^2}{dt^2}=\frac{dx^2+dy^2}{dt^2}$. Now, on differentiating the two equations (2), we get

$$\frac{dx}{dt}=a\cos A, \quad \frac{dy}{dt}=a\sin A-gt,$$

the squares of which being added together, give the following relation between the velocity and the time, viz.

$$v^2=a^2-2agt\sin A+g^2t^2.$$

At the point B we have $x=\text{AB}=4h\cos A\sin A$ by equation (5), and $y=0$. But from the equation $x=ta\cos A$, we have also $t=x\div a\cos A$; whence at the point B, $t=4h\sin A\div a$; therefore, since by formula I. $a^2=2gh$, $gt=$

Projectiles. $2a \sin A$. Substituting this value of gt in the above equation, we get

$$v^2 = a^2 - 4a^2 \sin^2 A + 4a^2 \sin^2 A = a^2;$$

so that the velocity in the parabola at the point B is equal to the initial velocity at A.

The angle under which the projectile meets the horizontal line AB, is also equal to the angle of elevation A. For since the tangent of the inclination of the curve to the axis of x is given in general by the equation

$$\frac{dy}{dx} = \tan A - \frac{x}{2h \cos^2 A},$$

we have at the point B, where $x = 4h \cos A \sin A$,

$$\frac{dy}{dx} = \tan A - \frac{2 \sin A}{\cos A} = \tan A - 2 \tan A = -\tan A.$$

From the equation (3) we readily deduce the solution of the following problem, which contains the most important practical application of the theory. Given the velocity of projection $= a$, it is required to determine A, the angle of elevation, in order that the projectile may hit a given mark, or that the trajectory may pass through a given point E.

Let β, γ be the co-ordinates of E, namely $AF = \beta$, $FE = \gamma$. From equation (3) we have

$$\gamma = \beta \tan A - \beta^2 \div 4h \cos^2 A,$$

and the object is to find from this equation the angle of elevation, or the value of A. Transposing, and observing that $1 \div \cos^2 A = 1 + \tan^2 A$, the equation becomes

$$\tan^2 A - \frac{4h}{\beta} \tan A = -\frac{4h\gamma}{\beta^2} - 1,$$

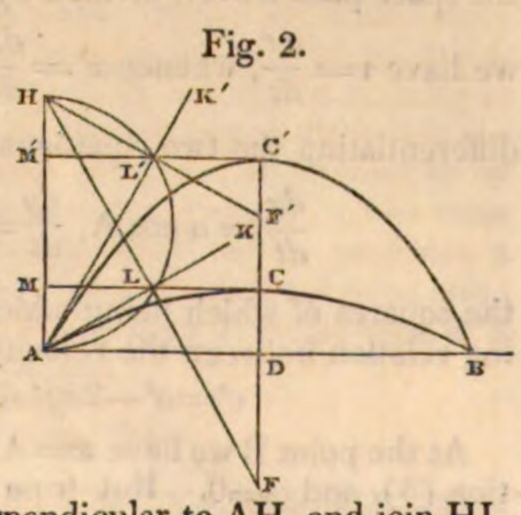
which being solved in respect of tan A, gives

$$\tan A = \frac{2h}{\beta} \pm \frac{1}{\beta} \sqrt{(4h^2 - 4h\gamma - \beta^2)}.$$

When the quantity under the radical sign is positive, that is, when $4h^2$ is greater than $4h\gamma + \beta^2$, then tan A has two values, and there are consequently two angles of elevation, by either of which the mark may be hit. If $4h^2 = 4h\gamma + \beta^2$, then $\tan A = 2h \div \beta$, and there is consequently only one angle of elevation; and if $4h^2$ be less than $4h\gamma + \beta^2$, then the quantity under the radical sign is negative, and the problem becomes impossible. It may be remarked that, supposing γ and β variable, the equation $4h^2 - 4h\gamma - \beta^2 = 0$, or $\beta^2 = 4h(h - \gamma)$ is the equation of a parabola, the axis of which is the vertical line AH, the focus at A, and the vertex at a point H, such that $AH = h$, the height corresponding to the given velocity of projection. For all points within this parabola β^2 is less than $4h^2 - 4h\gamma$, and consequently $4h^2$ greater than $4h\gamma + \beta^2$; and for all points without it β^2 is greater than $4h^2 - 4h\gamma$, or $4h^2$ less than $4h\gamma + \beta^2$, so that the parabola, whose equation is $\beta^2 = 4h(h - \gamma)$ forms the line of separation between the points within the range of a body projected from the point A with the velocity a, and which may be each hit by projecting the body under two different angles of elevation, and the points which the projectile cannot reach at all.

The different expressions which have been found in the preceding solution, may be represented by a very simple geometrical construction. On the vertical line passing through A, (fig. 2.) take $AH = h =$ height due to the velocity of projection a, and let AK be the initial direction. On AH describe a semicircle, meeting AK in L, make LM perpendicular to AH, and join HL. Since ALH is a right angle, and therefore AHL = LAB =

Fig. 2.



Projectiles. A, we have $AL = h \sin A$, $AM = AL \sin A = h \sin^2 A$; and $LM = AL \cos A = h \cos A \sin A$. Comparing these expressions with the equations (4), we have $x_1 = 2LM$, and $y_1 = AM$, x_1 and y_1 being the co-ordinates of the vertex. Hence the vertex of the parabola lies in the straight line ML, and is obtained by making LC = ML. It follows also from the equation (5), that AB, the horizontal range, is equal to 4ML. Projectiles.

Through L conceive a straight line to be drawn perpendicular to AB, or parallel to AH. This line will either be a tangent to the semicircle, or will meet it in another point L′. In the former case the angle of elevation is 45°, and there is only one parabola corresponding to the given velocity a, through which a projectile can pass to B. But when the horizontal range AB is less than twice the height AH due to the velocity, the vertical drawn through L again meets the circle in L′, and AL′ is the tangent to another parabola which passes through B, and of which the vertex is situated at the intersection of DC with M′L′ parallel to AB.

From the equation (3) the parameter of the parabola is $4h \cos^2 A$. But $DC = h \sin^2 A$; whence $DC + \frac{1}{4}$ parameter $= h$, and consequently $MH = \frac{1}{4}$ parameter. But (see Conic Sections, Part I. prop. xiv.) the distance of the directrix of a parabola from its vertex is equal to one-fourth of the parameter; and hence a straight line drawn through H parallel to AB is the common directrix of all the parabolas which can be described by a body projected from A with the velocity due to the height AH.

The focus of the parabola A C B is at the point F where H L meets the axis C D, and the focus of A C′ B at the point F′ where H L′ meets the axis; and if a circle be described about A as a centre, with a radius = A H, the foci of all the parabolas which can be described with the given velocity of projection, will be in the circumference of that circle.

These few simple propositions contain the whole theory of the motion of projectiles in vacuo, or independent on the resistance of the air; and being easily investigated, and connected with very interesting practice, they have been much commented on, and have furnished matter for many splendid volumes. But the air's resistance occasions such a prodigious diminution of motion in the great velocities of military projectiles, that this parabolic theory, as it is called, is hardly of any use. Mr. Robins found that a musket-ball, discharged with the usual allotment of powder, had the velocity of 1700 feet in a second. This requires a fall of 45,156 feet, and the range therefore should be 90,312, or $17\frac{1}{8}$ miles; whereas it does not much exceed half a mile. A twenty-four pound ball, discharged with sixteen pounds of powder, should range about sixteen miles; whereas it is generally short of three miles. It is only in the cases of slow motions, not exceeding 300 or 400 feet in a second, that the theory can be of any use, for then the path of the projectile differs little from a parabola.

In such experiments as can be performed with great accuracy in a chamber, the coincidence is as great as can be wished. A jet of water or mercury, gives us the finest example, because we have the whole parabola exhibited in the simultaneous places of the succeeding particles. Yet even in these experiments a deviation can be observed. When the jet is made on a horizontal plane, and the curve carefully traced on a perpendicular plane held close by it, it is found that the distance between the highest point of the curve and the mark is less than the distance between it and the spout, and that the descending branch of the curve is shorter than the ascending branch. And this difference is more remarkable as the jet is made with greater velocity, and reaches to a greater distance; and it is evidently produced by the resistance of the air, which diminishes the velocity, without affecting the gravity of a projectile. It is

Projectiles.

still more sensible in the motion of bombs. These can be traced through the air by the light of their fuzes; and we see that their highest point is always much nearer to the mark than to the mortar on a horizontal plane.

We now proceed to the problem of determining the path of a projectile in a resisting medium, and as the solution is attended with considerable difficulty, and cannot be obtained without the aid of the integral calculus, we shall endeavour to render it more perspicuous, by considering separately, 1st, the motion of a body allowed to fall from rest; 2d, of a body projected vertically upwards; and, lastly, the general case of a body projected with a given velocity in any direction oblique to the horizon. In order to simplify the subject, we shall suppose the density of the medium to be uniform, which may be considered to be the case of the atmosphere at all altitudes which can be reached by a projectile from the ground; and that the projected body is a sphere, either homogeneous, or composed of spherical strata, for each of which the density is uniform.

Suppose then the body to be let fall, or submitted to the action of gravity, and let R denote the force with which it is resisted at any given instant. By the principles of dynamics the corresponding accelerating force is equal to the moving force R divided by the mass of the body, (or the moving force referred to the unit of mass,) therefore the accelerating force due to the resistance is $R \div m$. As this force acts in the direction opposite to gravity, it must be taken with the negative sign, or deducted from g, and the whole accelerating force, causing the descent of the body being represented by φ, we have

$$\varphi = g - R \div m. \qquad (6)$$

It is necessary to remark, for the sake of preserving accurate principles, that a body descends in air, not by the whole of its weight, but by the excess of its weight above that of the air which it displaces. It descends by its *specific* gravity only as a stone descends in water. Suppose a body 32 times heavier than an equal bulk of air, it will be buoyed up by a force equal to 1–32d part of its weight; and, instead of acquiring the velocity of 32 feet in a second, it will only acquire a velocity of 31, even though it sustained no resistance from the inertia of the air. Let w be the weight of the body, and w' the weight of an equal bulk of air, then the *relative* acceleration of gravity will be correctly expressed by $g\left(1-\frac{w'}{w}\right)$. But in all practical cases, and particularly in the case of military projectiles, which have a great density, the fraction which enters into this expression is so small that it is not worth attending to.

In order to reduce the force $R \div m$ to its simplest expression, let r denote the radius of the sphere, and δ its mean density. Its volume is then $\frac{4}{3}\pi r^3$, (π being as usual the ratio of the circumference of a circle to its diameter,) and we have for the mass $m = \frac{4}{3}\pi\delta r^3$. With respect to the force R, the usual hypothesis is to suppose it to be proportional to the square of the velocity of the moving body, to the surface of the projectile, and also to the density of the air. If then we take ρ to represent the density of the air, and assume n = a numerical factor to be found by experiment, we shall have $R = n\rho . v^2 r^2$, and consequently

$$\frac{R}{m} = \frac{n\rho . v^2}{\delta r}. \qquad (7)$$

Since $R \div m$ is an accelerating force of the same nature as gravity, and may consequently be represented by a quantity of the same kind as g, we shall have a homogeneous expression by making $\frac{n\rho}{\delta r} = \frac{g}{b^2}$, b being a constant. The expression thus becomes $\frac{R}{m} = g\frac{v^2}{b^2}$; and it is necessary to observe that the constant b denotes the terminal velocity, or uniform final velocity which the body attains when the resistance becomes equal to gravity, or when $R \div m = g$, and it is consequently no longer urged by an accelerating or retarding force. For the resistance being assumed proportional to the square of the velocity, and $R \div m$ being the retarding force due to the velocity v, if b = the terminal velocity, the retarding force due to which is g, we shall have the proportion $b^2 : v^2 :: g : \frac{R}{m}$; whence $\frac{R}{m} = g\frac{v^2}{b^2}$.

Thus the retarding force due to any velocity v is expressed in terms of the terminal velocity, but the great difficulty is to procure an absolute measure of this quantity. Sir Isaac Newton has attempted to determine the resistance by theory, and employs a great part of the second book of the *Principia* in demonstrating, that the resistance to a sphere moving with any velocity, is to the force which would generate or destroy its whole motion in the time that it would uniformly move over $\frac{8}{3}$ of its diameter with this velocity, as the density of the air is to the density of the sphere. This is equivalent to demonstrating that the resistance of the air to a sphere moving through it with any velocity, is equal to half the weight of a column of air having a great circle of the sphere for its base, and for its altitude the height from which a body must fall in *vacuo* to acquire this velocity. This appears from Newton's demonstration; for, let the specific gravity of the air be to that of the ball as 1 to β; then, because the times in which the same velocity will be extinguished by the uniform action of different forces are inversely as the forces, the resistance to this velocity would extinguish it in the time of describing $\frac{8}{3}\beta d$, d being the diameter of the ball. Now 1 is to β as the weight of the displaced air to the weight of the ball, or as $\frac{2}{3}$ of the ball to the length of a column of air of equal weight. Call this length k; k is therefore equal to $\frac{2}{3}\beta d$. Suppose the ball to fall from the height k in the time t, and acquire the velocity u. If it moved uniformly with this velocity u during the time t, it would describe a space $= 2k$, or $\frac{4}{3}\beta d$. Now its weight would extinguish this velocity, or destroy this motion, in the same time, that is, in twice the time of falling. The resistance therefore is equal to half the weight of the ball, or to half the weight of the column of air whose height is the height producing the velocity. But the resistances to different velocities are as the squares of the velocities, and therefore, as their producing heights; and, in general, the resistance of the air to a sphere moving with any velocity, is equal to the half weight of a column of air of equal section, and whose altitude is the height producing the velocity. The result of this investigation has been acquiesced in by all Sir Isaac Newton's commentators. Many faults have indeed been found with his reasoning, and even with his principles; and it must be acknowledged that his reasoning is liable to serious objections, which his most ingenious commentators have not completely removed. We must add, however, that all the causes of deviation from the duplicate ratio of the velocities, and the causes of increased resistance, which the latter authors have valued themselves for discovering and introducing into their investigations, were pointed out by Sir Isaac Newton, but purposely omitted by him, in order to facilitate the discussion *in re difficillima*. (See *Schol.* prop. 37. book ii.)

It is known that the weight of a cubic foot of water is $62\frac{1}{2}$ pounds, and that the medium density of the air is $\frac{1}{840}$ of water; therefore, let h be the height producing the velocity (in feet), and d the diameter of the ball (in inches), and π the periphery of a circle whose diameter is 1; the resistance of the air will be $= \frac{62\frac{1}{2}}{840} \times \frac{\pi}{4} \times \frac{d^2}{144} \times \frac{h}{2} =$

Projectiles. $\frac{hd^2}{4928\frac{1}{2}}$ pounds, very nearly, or, since by formula III. $h=v\div 2g$, resistance$=\frac{v^2d^2}{4928\frac{1}{2}\times 64}=\frac{v^2d^2}{315417}$ pounds.

We may take an example. A ball of cast iron weighing 12 pounds, is $4\frac{1}{2}$ inches in diameter. Suppose this ball to move at the rate of $25\frac{1}{3}$ feet in a second (the reason of this choice will appear afterwards). The height which will produce this velocity in a falling body is $9\frac{7}{8}$ feet. The area of its great circle is 0·11044 feet, or $\frac{11044}{100000}$ of one foot. Suppose water to be 840 times heavier than air, the weight of the air incumbent on this great circle, and $9\frac{7}{8}$ feet high, is 0·081151 pounds; half of this is 0·0405755, or nearly $\frac{1}{25}$ of a pound. This should be the resistance of the air to this motion of the ball.

Newton himself attempted to compare his propositions with experiment. Some were made by dropping balls from the dome of St. Paul's cathedral; and all these shewed as great a coincidence with his theory as they did with each other; but the irregularities were too great to allow him to say with precision what was the resistance. It appeared to follow the proportion of the squares of the velocities with sufficient exactness; and though he could not say that the resistance was equal to the weight of the column of air having the height necessary for communicating the velocity, it was always equal to a determinate part of it; and might be stated $=n\,h$, n being a number to be fixed by numerous experiments.

Newton made another set of experiments with pendulums; and has pointed out some very curious and unexpected circumstances of their motions in a resisting medium. Their results were much more uniform, and confirmed his general theory; which, as we have said above, has been acquiesced in by the first mathematicians.

But the deductions from this theory were so inconsistent with the observed motions of military projectiles, when the velocities are prodigious, that no application could be made which could be of any service for determining the path and motion of cannon shot and bombs; and although John Bernoulli gave, in 1718, a most elegant determination of the trajectory and motion of a body projected in a fluid which resists in the duplicate ratio of the velocities, it has remained a dead letter. Mr. Benjamin Robins was the first who suspected the true cause of the imperfection of the usually received theories; and in 1737 he published a small tract, in which he showed clearly, that even the Newtonian theory of resistance must cause a cannon ball, discharged with a full allotment of powder, to deviate farther from the parabola, in which it would move *in vacuo*, than the parabola deviates from a straight line. But he farther asserted, on the authority of good reasoning, that in such great velocities the resistance must be much greater than this theory assigns; because, besides the resistance arising from the *inertia* of the air which is put in motion by the ball, there must be a resistance arising from a condensation of the air on the anterior surface of the ball, and a rarefaction behind it; and there must be a third resistance, arising from the statical pressure of the air on its anterior part, when the motion is so swift that there is a vacuum behind. Even these causes of disagreement with the theory had been foreseen and mentioned by Newton (see the Scholium to prop. 37, book ii. *Princip.*); but the subject seems to have been little attended to.

Two or three years after this first publication, Mr. Robins invented that ingenious method of measuring the great velocitics of military projectiles, which has handed down his name to posterity, and discovered the prodigious resistance of the air by observing the diminution of velocity which it occasioned. This made him anxious to examine what was the real resistance to any velocity whatever, in order to ascertain what was the law of its variation; and he was equally fortunate in this attempt. His method of measuring the resistance has been fully described in the article Gunnery. Projectiles.

It appears (Robins's *Math. Works*, vol. i. p. 205,) that a sphere of $4\frac{1}{2}$ inches in diameter, moving at the rate of $25\frac{1}{3}$ feet in a second, sustained a resistance of 0·04914 pounds, or $\frac{4914}{100000}$ of a pound. This is a greater resistance than that of the Newtonian theory, which gave 0·0405755, in the proportion of 1000 to 1211, or very nearly in the proportion of five to six in small numbers. And we may adopt as a rule in all moderate velocities, that the resistance to a sphere is equal to $\frac{61}{100}$ of the weight of a column of air having the great circle of the sphere for its base, and for its altitude the height through which a heavy body must fall *in vacuo* to acquire the actual velocity.

This experiment is peculiarly valuable, because the ball is precisely the size of a 12-pound shot of cast iron; and its accuracy may be depended on. There is but one source of error. The whirling motion must have occasioned some whirl in the air, which would continue till the ball again passed through the same point of its revolution. The resistance observed is therefore probably somewhat less than the true resistance to the velocity of $25\frac{1}{3}$ feet, because it was exerted in a relative velocity which was less than this, and is, in fact, the resistance due to this relative and smaller velocity. The Chevalier de Borda made experiments similar to those of Mr. Robins, and his results exceed those of Robins in the proportion of 5 to 6. It is much to be regretted, that in a subject so interesting both to the philosopher and the engineer, experiments have not been multiplied. Nothing would tend so much to perfect the science of gunnery, and indeed until this be done, no practical advantage can be derived from the theory.

Adopting this experimental measure of Robins, we have the product $n\rho$ of equation (7) $=$·04914 pounds in respect of a sphere of $4\frac{1}{2}$ inches diameter, or 2·25 inches radius, moving at the rate of 25·2 feet in a second. In order to determine from this experiment the resistance on a sphere of a different size, and moving with a different velocity, it will be convenient to reduce it to the case corresponding to the units of magnitude and velocity; therefore, since the resistance is assumed proportional to the square of the velocity and the surface of the projectile, or $R=n\rho v^2r^2$, if we denote by R_1 the corresponding resistance, in respect of a sphere whose radius is 1 inch, moving with the velocity of 1 foot per second, we shall have

$$R_1=n\rho=\frac{\cdot 04914}{(2\cdot 25)^2\times(25\cdot 2)^2}=\cdot 000015285 \text{ pounds.}$$

The logarithm of this number is 5·18427. The resistance here determined is independent of the density of the ball; but the retardation occasioned by it being in proportion to the quantity of motion, will therefore be proportional to the density of the ball, or its specific gravity. Military projectiles are of cast iron or lead, the specific gravities of which may be taken at 7·207, and 11·37 respectively, that of water being 1.

The following examples will illustrate the application of the above formula.

1. Let it be proposed to find the resistance to a 24-pound iron ball (whose diameter is 5·603 inches), moving with the velocity of 1670 feet in a second, which is nearly the velocity communicated by 16 lbs. of gunpowder.

Here $v=1670$, $r=2\cdot 8015$, and the formula $R=n\rho v^2r^2$ gives

$$R=\cdot 000015285\times(1670)^2\times(2\cdot 8015)^2=334\cdot 57 \text{ lbs.}$$

But it is found, by unequivocal experiments, that the retardation of such a motion, is equivalent to 504 lbs. This is owing to the causes often mentioned, the additional resist-

Projectiles. ance to great velocities, arising from the condensation of the air, and from its pressure in o the vacuum left by the ball.

2. Let the terminal velocity of the same ball be required. Here the equation (7) gives $\frac{R}{m}=g\frac{v^2}{b^2}$; therefore in respect of the ball whose velocity is 1 and radius 1, we have $R_1=mg\div b^2$, b being the terminal velocity. Now it is to be observed that the product of the mass of a body into the force of gravity expresses its weight, which we may denote by w; we have then $R_1=w\div b^2$, and consequently $b^2=w\div R_1$. Now in respect of another body of the same specific gravity, whose radius is r, we have $R:R_1::r^2:1$, whence $R=R_1r^2$, and the equation becomes $b^2=w\div R_1r^2$. Substituting in this equation the numbers given in the question, we get

$$b^2=\frac{24}{\cdot000015285\times(2\cdot8015)^2}=200060,$$

whence $b=447\cdot3$ feet.

As the terminal velocity b, and its producing height k, enter into all computations of military projectiles, we have inserted the following Table for the usual sizes of cannon-shot, computed both by the Newtonian theory of resistance, and by the resistances observed in Robins's experiments. A similar table, computed from Dr. Hutton's experiments, and not materially different, is given in *Hutton's Tracts*, vol. iii. p. 247.

Lb. Ball.	Newton.		Robins.		Diam. Inch.
	b Term Vel.	$2k$.	b Term Vel.	$2k$.	
1	289·9	2626·4	263·4	2168·6	1·94
2	324·9	3298·5	295·2	2723·5	2·45
3	348·2	3788·2	316·4	3127·9	2·80
4	365·3	4170·3	331·9	3442·6	3·08
6	390·8	4472·7	355·1	3940·7	3·52
9	418·1	5463·5	379·9	4511·2	4·04
12	438·6	6010·6	398·5	4962·9	4·45
18	469·3	6883·3	426·5	5683·5	5·09
24	492·4	7576·3	447·4	6265·7	5·61
32	512·6	8024·8	465·8	6780·4	6·21
42	540·5	9129·9	491·5	7538·3	6·75

Having thus explained the nature of the quantities employed in the investigation, we now proceed with the solution of the problem of determining the circumstances of the motion of a body falling vertically in the atmosphere. In consequence of the equation $\frac{R}{m}=g\frac{v^2}{b^2}$, the relation between the accelerating force and the resistance given by equation (6), becomes $\phi=g-g\frac{v^2}{b^2}=g\frac{b^2-v^2}{b^2}$. Hence from the second of equations (1), $\frac{dv}{dt}=g\frac{b^2-v^2}{b^2}$, whence $gdt=\frac{b^2dv}{b^2-v^2}$, or, which is the same, $gdt=\frac{b}{2}\left(\frac{dv}{b+v}+\frac{dv}{b-v}\right)$.

On integrating this equation, and observing that as t and v commence together no correction is required, we get $gt=\frac{1}{2}b\{\log(b+v)-\log(b-v)\}$, whence

$$t=\frac{b}{2g}\log\frac{b+v}{b-v}. \qquad (8)$$

From this equation the time t during which a body must fall in a resisting medium in order to acquire the velocity v, is readily computed, supposing the terminal velocity b to be known. It will be observed that the logarithm is hyperbolic, and therefore, if the common tables are used, the tabular logarithm of the number in question must be divided by the modulus of the system M=·43429 (see LOGARITHMS, vol. xiii. p. 429). The terminal velocity b, as appears by equation (7), varies with the radius of the ball, and the ratio of its density to that of the air, and must be determined by experiment. Projectiles.

As an example of the formula, assume the terminal velocity $=689\frac{1}{3}$ feet in a second, and let it be proposed to determine the time in which the body will acquire a velocity of 323·62 feet per second.

Here $b=689\cdot33$, $v=323\cdot62$, $b+v=1012\cdot95$, $b-v=365\cdot71$, whence the common logarithm of $\frac{b+v}{b-v}$ is 0·44245 and hyp. log $\frac{b+v}{b-v}=\frac{44245}{43429}$. Now $b\div2g=689\cdot33\div64=10\cdot77$, therefore $t=10\cdot77\times\frac{44245}{43429}=10\cdot97$ seconds, which is the time required.

Assume $\tau=gt\div b$, and let e denote the base of the Napierean or hyperbolic logarithms, that is, let $e=2\cdot71828$; the equation (8) gives, on passing to numbers $e^{2\tau}=\frac{b+v}{b-v}$, or $e^{-2\tau}=\frac{b-v}{b+v}$, whence $v=\frac{b(1-e^{-2\tau})}{1+e^{-2\tau}}$. Let the terms of this expression for v be multiplied by e^{τ} and the equation becomes

$$v=\frac{b(e^{\tau}-e^{-\tau})}{e^{\tau}+e^{-\tau}} \qquad (9)$$

which gives the velocity in terms of τ, that is, in terms of the time t, and the terminal velocity b.

To find the space described, the equations (1) give $vdt=dx$. Now we have assumed $gt\div b=\tau$, therefore $gdt=bd\tau$, whence and from equation (9)

$$gdx=\frac{b^2(e^{\tau}-e^{-\tau})dt}{e^{\tau}+e^{-\tau}}.$$

The integral of this is $gx=b^2\log(e^{\tau}+e^{-\tau})+C$, (C being a constant). When $x=0$, then $v=0$, and the equation becomes $0=b^2\log2+C$; therefore the complete integral is

$$x=\frac{b^2}{g}\log\tfrac{1}{2}(e^{\tau}+e^{-\tau}) \qquad (10)$$

which gives the space in terms of the time and final velocity.

The space may also be expressed in terms of the velocity. From equations (1) we have $vdt=dx$ and $\phi dt=dv$. Eliminating dt between these two equations we get $\phi dx=vdv$. But $\phi\left(=\frac{dv}{dt}\right)=g\frac{b^2-v^2}{b^2}$, therefore $gdx=\frac{b^2vdv}{b^2-v^2}$. The integral of this gives $gx=-\frac{1}{2}b^2\log(b^2-v^2)+C$. To determine the constant, we have $v=0$, when $x=0$, and therefore $0=-b^2\log(b^2+C)$; whence the complete integral is $gx=\frac{1}{2}b^2\{\log b^2-\log(b^2-v^2)\}$, or

$$x=\frac{b^2}{2g}\log\frac{b^2}{b^2-v^2}. \qquad (11)$$

As an example of this formula, suppose, as above, $b=689\frac{1}{3}$ feet, and let it be required to find the space through which the body has descended when the acquired velocity $v=323.62$ feet. Here the common logarithm of b^2 is 5.67686, and that of b^2-v^2 is 5.56872; therefore the common logarithm of $b^2\div(b^2-v^2)$ is 0.10814, and its hyperbolic logarithm $=\frac{10814}{43429}$. We have also $b^2\div2g=7429.6$

Projectiles. feet, therefore $x=7429.6\times\frac{10814}{43429}=1850$ feet per second.

The formula may also be computed by means of the trigonometrical tables; for since $\frac{1}{2}\log\frac{b^2}{b^2-v^2}=\log\sqrt{\frac{b^2}{b^2-v^2}}$ = logarithmic secant of an arc whose radius is b and sine v, or of an arc whose radius is 1 and sine $=v\div b$, if we seek in the table the arc whose logarithmic sine $=\log(v\div b)$, its logarithmic secant, or the logarithm of its cosine subtracted from unity, and divided by the modulus M $=.43429$, will be the value of $\frac{1}{2}\log\frac{b^2}{b^2-v^2}$. Thus in the last example we have the common logarithm of $1v\div b=9.67160$, which corresponds to an arc of 28°. Now log cos 28°=9.94593, whence log secant 28°=0.05407. But $b^2\div g=14859.2$ (the double of $b^2\div 2g$ or 7429.6 found above), therefore $x=148592\times\frac{5407}{43429}=1850$ feet, as before.

In this manner the equation (11) will also give the velocity when the space x is known. For let ψ denote the arc whose logarithmic sine in the common tables is $\log(v\div l)$, and the equation becomes $x=\frac{b^2}{g\mathrm{M}}$ log secant ψ, whence log sec. $\psi=\frac{g\mathrm{M}x}{b^2}$. Having therefore found ψ corresponding to this secant, we shall have $v\div b=\sin\psi$, and consequently $v=b\sin\psi$. Suppose, as before, $b=689\frac{1}{3}$ feet, and let it be required to find the velocity when the body has fallen 1850 feet. Here $\frac{g\mathrm{M}x}{b^2}=\frac{32\times.43429\times1850}{(689\frac{1}{3})^2}=.05407$, which is the logarithmic secant of ψ; but $1-.05407=.94593=\log\cos\psi$, whence ψ is found in the tables $=28°$, and $\log\sin\psi=9.67160$. Adding $\log b=2.83843$, we have $\log b\sin\psi=2.51003$, whence $v=b\sin\psi=323.62$ feet.

We come now to consider the case of a body, supposed, as before, to be a sphere of given magnitude and density, projected vertically upwards. In this case the resistance of the air and the force of gravity act both in the same direction, and the accelerating force becomes $\phi=-g-\frac{gv^2}{b^2}$; whence, since $\phi=dv\div dt$, we obtain the equation

$$\frac{bdv}{b^2+v^2}=-\frac{gdt}{b}.$$

To integrate the first member of this equation, let ψ denote an arc of a circle, then $d\tan\psi=d\psi\div\cos^2\psi$. Now let $\tan\psi=v\div b$, then $d\tan\psi=dv\div b$, and $1\div\cos^2\psi=1+\tan^2\psi=\frac{b^2+v^2}{b^2}$, and we get $d\psi=\frac{bdv}{b^2+v^2}$, whence

$$\int\frac{bdv}{b^2+v^2}=\psi=\text{arc}\left(\tan=\frac{v}{b}\right)$$

and the integral of the above equation becomes

$$\text{arc}\left(\tan=\frac{v}{b}\right)=-\frac{gt}{b}+\mathrm{C}.$$

To determine the constant, let a as before denote the initial velocity. When $v=a$, then $t=0$, and we have

$$\text{arc}\left(\tan=\frac{a}{b}\right)=+\mathrm{C},$$

therefore the complete integral is $\text{arc}\left(\tan=\frac{v}{b}\right)=\text{arc}\left(\tan=\frac{a}{b}\right)-\frac{gt}{b}$, whence

$$t=\frac{b}{g}\left\{\text{arc}\left(\tan=\frac{a}{b}\right)-\text{arc}\left(\tan=\frac{v}{b}\right)\right\},\quad(12)$$

Projectiles.

which gives the relation between the velocity and time. The quantities within the brackets express a portion of the arc of a circle whose radius is unit, and are therefore abstract numbers, multiplying $b\div g$, which is the number of units of time in which a heavy body falling in vacuo, acquires the velocity b, by formula 11.

Assume, as above, $\frac{gt}{b}=\tau$, and make $\frac{a}{b}=\tan\alpha$, $\frac{v}{b}=\tan\beta$; the equation (12) then becomes $\beta=\alpha-\tau$, whence by trigonometry

$$\tan\beta=\frac{\tan\alpha-\tan\tau}{1+\tan\alpha\tan\tau}.$$

On substituting for α and β their values as above, this gives

$$\frac{v}{b}=\frac{\frac{a}{b}-\frac{\sin\tau}{\cos\tau}}{1+\frac{a}{b}\frac{\sin\tau}{\cos\tau}},$$

$$\text{whence } v=\frac{b(a\cos\tau-b\sin\tau)}{a\sin\tau+b\cos\tau}.$$

Now, since $gt=b\tau$, we have $gdt=bd\tau$, and consequently

$$gvdt=\frac{b^2(a\cos\tau-b\sin\tau)d\tau}{a\sin\tau+b\cos\tau};$$

therefore, integrating, and observing that $\int vdt=x$, we have

$$gx=b^2\log(a\sin\tau+b\cos\tau)+\mathrm{C}.$$

When $x=0$, then $t=0$, $\tau=0$, $\sin\tau=0$, $\cos\tau=1$; therefore $0=b^2\log b+\mathrm{C}$, and the complete integral becomes

$$gx=b^2\{\log(a\sin\tau+b\cos\tau)-\log b\},$$

or

$$gx=b^2\left(\log\frac{a}{b}\sin\tau+\cos\tau\right);$$

whence on restoring the value of τ,

$$x=\frac{b^2}{g}\log\left(\frac{a}{b}\sin\frac{gt}{b}+\cos\frac{gt}{b}\right),\quad(13)$$

which gives the space described in a function of the time.

To express the space in terms of the velocity, we have $\phi dx=vdv$. But in this case $\phi=-g\frac{(b^2+v^2)}{b^2}$, therefore,

$$dx=-\frac{b^2}{g}\cdot\frac{vdv}{b^2+v^2}.$$

The integral of this gives $2gx=-b^2\log(b^2+v^2)+\mathrm{C}$; and when $x=0$, then $v=a$; therefore $0=-b^2(b^2+a)+\mathrm{C}$, and the complete integral becomes

$$x=\frac{b^2}{2g}\log\frac{b^2+a^2}{b^2+v^2}.\quad(14)$$

Let h denote the greatest altitude. When the projectile reaches this altitude, $v=0$, and the last equation gives

$$h=\frac{b^2}{2g}\log\frac{b^2+a^2}{b^2}.\quad(15)$$

This formula may be computed from the trigonometrical tables, by observing that $\frac{1}{2}\log\frac{b^2+a^2}{b^2}=\log\sqrt{\frac{b^2+a^2}{b^2}}=$ logarithmic secant of an arc ψ of which the tangent is $a\div b$. Suppose the velocity of projection to be 411 feet per se-

Projectiles. cond, and $b=689\frac{1}{3}$, the calculation of the height h will be as follows:

$$\log a = \log 411 = 2{\cdot}61384$$
$$\log b = \log 689\tfrac{1}{3} = 2{\cdot}83843$$
$$\log \tan \psi = 9{\cdot}77541$$

From the table of logarithmic tangents we find $\psi = 30°48'20''$, the logarithmic cosine of which is 9·93395, whence log sec $\psi = 0{\cdot}06605$. We have therefore $h = \frac{b^2 \times {\cdot}06605}{gM} = \frac{(689\frac{1}{3})^2 \times {\cdot}06605}{32 \times {\cdot}43429} = 2259$ feet.

Having reached the greatest altitude h, the body will immediately begin to fall. From equation (11) we have $x = \frac{b^2}{2g} \log \frac{b^2}{b^2 - v^2}$ for the space through which the body must fall to acquire the velocity v. Now, if we make $x=h$, we shall have, on comparing this with the equation (15) $\log \frac{b^2+a^2}{b^2} = \log \frac{b^2}{b^2-v^2}$, whence $\sqrt{\frac{b^2+a^2}{b^2}} = \sqrt{\frac{b^2}{b^2-v^2}}$.

But the first number of this equation is the secant of an arc, whose tangent is $a \div b$, and the second the secant of an arc whose sine is $v \div b$; and since the secants are equal, the arcs must be equal; therefore the velocity of projection is to the final returning velocity as the tangent to the sine, or as the radius to the cosine of an arc. Suppose the body projected with a velocity equal to the terminal velocity, that is, suppose $a=b$; the above equation will then become $2(b^2-v^2) = b^2$, or $b^2 = 2v^2$, whence $v = b \div \sqrt{2}$. If $b=689\frac{1}{3}$, then $v=487$, or the body will reach with a velocity of 487 feet per second.

The time required for reaching the greatest altitude is found by making $v=0$ in equation (12). In this case the equation becomes $t = \frac{b}{g}$ arc $\left(\tan = \frac{a}{b}\right)$. We learn from this expression of the time, that however great the velocity of projection, and the height to which the body will rise, may be, the time of its ascent is limited. It never can exceed the time of falling *in vacuo* from the height due to the terminal velocity b, namely $t = b \div g$, in a greater proportion than that of a quadrantal arc to the radius, nearly the proportion of 8 to 5. A 24-pound iron ball cannot continue rising above 14 seconds, even if the resistance to quick motions did not increase faster than the square of the velocity. It probably will attain its greatest height in less than 12 seconds, let its velocity be ever so great.

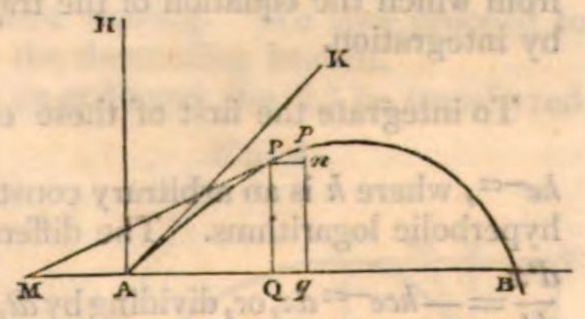
Having thus determined the relations subsisting between the velocity, the space described, and the time, in the cases of vertical ascent and descent in a resisting medium, we come now to consider the general problem, and to determine the motion of a body projected in any direction whatever. Our readers will readily conceive that this must be a difficult subject, when they see the simplest cases of rectilineal motion abundantly abstruse. In the infancy of the fluxionary calculus, the difficulty was indeed such that Newton himself did not succeed in obtaining a complete solution of the problem. In the tenth and subsequent propositions of the second book of the *Principia*, he shows what state of density in the air will comport with the motion of a body in any curve whatever; and then, by applying this result to several curves which have some similarity to the path of a projectile, he found one which is not very different from what may be supposed to obtain in the atmosphere. But even the approximation was involved in calculations of such intricacy, that it seemed impossible to make any use of it. In the second edition of the *Principia*, published in 1713, he corrects some mistakes into which he had fallen in the first, and carries the approximation much farther, but still does not attempt a direct investigation of the trajectory. In proposition 14, &c. he shows how a body, actuated by a centripetal force, in a medium of a density varying according to certain laws, will describe an eccentric spiral, of which he assigns the properties, and the law of description. Had he supposed the density constant, and the difference between the greatest and least distances from the centre of centripetal force exceedingly small in comparison with the distances themselves, his spiral would have coincided with the path of a projectile in the air of uniform density, and the steps of his investigation would have led him immediately to the complete solution of the problem. For this is the real state of the case. A heavy body is not acted on by equal and parallel gravity, but by a gravity inversely proportional to the square of the distance from the centre of the earth, and in lines tending to that centre nearly; and it has been only with the view of simplifying the investigation, that mathematicians have adopted the other hypothesis. Projectiles.

Soon after the publication of this second edition of the *Principia*, the dispute about the invention of the fluxionary calculus became very violent, and the great promoters of that calculus upon the continent were in the habit of proposing difficult problems as trials of skill to each other. Challenges of this kind frequently passed between the British and foreigners. Dr. Keill of Oxford had keenly espoused the claim of Sir Isaac Newton to this invention, and had engaged in a very acrimonious altercation with the celebrated John Bernoulli of Basle. Bernoulli had published in the *Acta Eruditorum* of Leipsic an investigation of the law of the forces, by which a body moving in a resisting medium might describe any proposed curve, reducing the whole to the simplest geometry; and Dr. Keill proposed to him the particular problem of the trajectory and motion of a body moving through the air. Bernoulli very soon solved the problem in a way much more general than it had been proposed, viz. without any limitation either of the law of resistance, the law of the centripetal force, or the law of density, provided only that they were regular, and capable of being expressed algebraically. Dr. Brook Taylor, the celebrated author of *The Method of Increments*, solved it at the same time, in the limited form in which it was proposed. Other authors since that time have given other solutions. But they are all (as indeed they must be) the same in substance with Bernoulli's. Indeed they are all (Bernoulli's not excepted) the same with Newton's first approximations, modified by the steps introduced into the investigation of the spiral motions mentioned above.

We now proceed to the problem itself, restricted to the case of uniform density and a resistance proportional to the square of the velocity.

Problem. To determine the trajectory, and all the circumstances of the motion of a body projected through the air, from a given point, and in a given direction, and resisted in the duplicate ratio of the velocity.

Fig. 3.



Suppose the body to be projected from A, in the direction AK, with a velocity $= a$, and let AB and AH, horizontal and vertical lines drawn through A, be assumed as the axes of the rectangular co-ordinates x and y. Let P be the place of the projectile at the end of the time t, make the arc $AP=z$, and let $Pp=dz$, be an infinitely small portion of the arc, which may be regarded as coinciding with PM, the tangent to the curve at P; draw PQ and pq parallel to AH, and Pn parallel to AB, and let the angle pPn (=PMA, which the tangent makes with the horizontal

Projectiles. axis), be denoted by θ; we have then $Pn=dx$, $np=dy$, and $dy=dx\tan\theta$.

The intensity of the force of resistance being denoted as before by R, and the mass of the projectile by m, the accelerating force due to the resistance is $R\div m$. This force is exerted in the direction of the tangent at P, and as it tends to diminish the velocity in the direction Pp, it must be taken with the negative sign. Now, the accelerating force in the direction Pp, is to the accelerating force in the direction Pn as 1 : $\cos\theta$, and to the force in the direction np as 1 : $\sin\theta$; therefore in the direction of the axis x the accelerating force is $(R\div m)\cos\theta$, and in the direction of the axis y, $(R\div m)\sin\theta$. But $\cos\theta=\frac{dx}{dz}$, and $\sin\theta=\frac{dy}{dz}$, therefore the accelerating forces due to the resistance, in the direction of the co-ordinates, are $-\frac{R}{m}\cdot\frac{dx}{dz}$ and $-\frac{R}{m}\cdot\frac{dy}{dz}$ respectively. In the horizontal direction, the sole force acting on the projectile is that which is due to the resistance; in the vertical direction the body is also acted on by the accelerating force of gravity, g, which, when the body is ascending, acts in the same direction with the resisting force of the atmosphere, and must therefore be taken with the same sign. Now, the accelerating forces in the directions x and y, are respectively $\frac{d^2x}{dt^2}$ and $\frac{d^2y}{dt^2}$ by equations (1); we have therefore for the equations of motion,

$$\frac{d^2x}{dt^2}=-\frac{R}{m}\cdot\frac{dx}{dz},\quad \frac{d^2y}{dt^2}=-g-\frac{R}{m}\cdot\frac{dy}{dz}. \tag{16}$$

Assuming $r=$ radius of the projectile, $\delta=$ its density, $\rho=$ density of atmosphere, $v=$ velocity at the point P, and $n=$ a constant co-efficient, we have, $\frac{R}{m}=\frac{n\rho}{\delta r}v^2$ by equation (7). In the case of the vertical motion, we represented the co-efficient of v^2 by the fraction $g\div b^2$, (b being the terminal velocity); it will now be more convenient to denote it by a single letter; we shall therefore assume $c=n\rho\div\delta r$; and consequently, as n and the ratio $\rho\div\delta$ are both abstract numbers, the reciprocal of the constant c, or $1\div c$, will represent a straight line; in fact, the reciprocal of c is twice the altitude producing the terminal velocity b *in vacuo*, for calling h' this altitude, we have by formula (III.) $b^2=2gh'$, therefore $g\div b^2=1\div 2h'=c$. We have then $R\div m=cv^2$; whence, since $v=\frac{dz}{dt}$, $\frac{R}{m}=\frac{dz^2}{dt^2}$. Substituting this in the above equations of motion (16) we get

$$\frac{d^2x}{dt^2}+c\frac{dz}{dt}\cdot\frac{dx}{dt}=0 \tag{17}$$
$$\frac{d^2y}{dt^2}+c\frac{dz}{dt}\cdot\frac{dy}{dt}+g=0,$$

from which the equation of the trajectory must be deduced by integration.

To integrate the first of these equations, suppose $\frac{dx}{dt}=ke^{-cz}$, where k is an arbitrary constant, and e the base of the hyperbolic logarithms. The differential of this equation is, $\frac{d^2x}{dt}=-kce^{-cz}dz$, or, dividing by dt, and substituting for ke^{-cz} its value, $\frac{d^2x}{dt^2}=-c\frac{dz}{dt}\cdot\frac{dx}{dt}$, which is the first of the above equations. Hence the integral of that equation is $\frac{dx}{dt}=ke^{-cz}$.

To determine the constant k, suppose $z=0$. When $z=0$, the velocity in the direction of the tangent AK is the initial velocity a, and in the direction AB it is $a\cos A$, assuming A as before to represent the angle KAB. But $\frac{dx}{dt}=v$, the velocity at P, therefore when $z=0$, the equation $\frac{dx}{dt}=ke^{-cz}$ gives $a\cos A=k$. The complete integral of the first of the equations (17) is therefore

$$\frac{dx}{dt}=a\cos A\,e^{-cz}. \tag{18}$$

The integral of the second equation (17) is found as follows. Since $dy=\tan\theta\,dx$, we have, on supposing x and y to be functions of t, $\frac{dy}{dt}=\tan\theta\frac{dx}{dt}$. Differentiating this equation, and observing that $d\tan\theta=\frac{d\vartheta}{\cos^2\vartheta}=\sec^2\vartheta\,d\theta$, we get $\frac{d^2y}{dt^2}=\frac{d\vartheta}{\cos^2\theta dt}\cdot\frac{dx}{dt}+\tan\theta\frac{d^2x}{dt^2}$. Substituting these values of $\frac{d^2y}{dt^2}$ and $\frac{dy}{dt}$ in the equation in question, it becomes

$$\frac{d\vartheta}{\cos^2\theta dt}\cdot\frac{dx}{dt}+\tan\theta\left\{\frac{d^2x}{dt^2}+c\frac{dz}{dt}\cdot\frac{dx}{dt}\right\}+g=0;$$

whence, by reason of the first of the equations (17)

$$\frac{d\vartheta}{\cos^2\theta dt}\cdot\frac{dx}{dt}+g=0; \tag{19}$$

and on dividing by $\frac{dx^2}{dt^2}=a^2\cos^2A\,e^{-2cz}$ (18), we get

$$\frac{d\vartheta}{\cos^2\vartheta dt}\div\frac{dx}{dt}=\frac{-g}{a^2\cos^2A}e^{-2cz}.$$

Now if θ be regarded as a function of x, then $\frac{d\vartheta}{dt}\div\frac{dx}{dt}=\frac{d\vartheta}{dx}$; and from the formula (III.) we have also $a^2=2hg$ (h being the height due to the velocity a); therefore by substitution

$$\frac{d\vartheta}{\cos^2\vartheta dx}=\frac{1}{2h\cos^2A}e^{2cz}$$

But we have $dx=dz\cos\theta$, therefore this equation becomes

$$\frac{d\theta}{\cos^3\vartheta}=-\frac{dz}{2h\cos^2A}e^{2cz}, \tag{20}$$

which is the differential equation of the trajectory.

The integral of this equation is found as follows. By Fluxions (*Art.* 153), $\int\frac{d\vartheta}{\cos^3\vartheta}=\frac{\sin\theta}{2\cos^2\vartheta}+\frac{1}{2}\int\frac{d\theta}{\cos\theta}$; and (*Art.* 155), $\int\frac{d\theta}{\cos^2\theta}=\log\tan(45°+\frac{1}{2}\theta)$ We have also $\int e^{2ez}\,dz=\frac{1}{2c}e^{2cz}$; therefore assuming K to denote an arbitrary constant, the general integral becomes

$$\frac{\sin\theta}{\cos^2\theta}+\log\tan(45°+\tfrac{1}{2}\theta)=K-\frac{1}{2ch\cos^2A}e^{2cz}.$$

To determine the constant, suppose $z=0$. When $z=0$ then $\theta=A$, and the last equation gives

$$K=\frac{1}{2ch\cos^2A}+\frac{\sin A}{\cos^2A}+\log\tan(45°+\tfrac{1}{2}A). \tag{21}$$

For the sake of abridging, let us assume

$$F(\vartheta)=\frac{\sin\theta}{\cos^2\theta}+\log\tan(45°+\tfrac{1}{2}\theta), \tag{22}$$

Projectiles.

$$F(A)=\frac{\sin A}{\cos^2 A}+\log\tan(45°+\tfrac{1}{2}A),$$

then the complete integral of equation (20) becomes $F(\theta)$

$$-F(A)=\frac{1}{2ch\cos^2 A}(1-e^{2cz}); \text{ whence, by transposition,}$$

$$e^{2cz}-1=2ch\cos^2 A\{F(A)-F(\theta)\}, \qquad (23)$$

an equation which gives the length z of the arc AP in terms of the angle which the tangent at P makes with the horizontal line AB.

We have now to find expressions for the co-ordinates x and y. In consequence of the equation (21), the last may be otherwise written

$$\frac{1}{2h\cos^2 A}e^{2cz}=c\{K-F(\theta)\}. \qquad (24)$$

Substituting this in (20) we get $\frac{d\vartheta}{\cos^3\vartheta}=-dzc\{K-F(\theta)\}$,

whence $dz=\frac{d\vartheta}{c\cos^3\vartheta\{F(\theta)-K\}}$. Now, we have also $dx=dz\cos\theta$, $dy=dz\sin\theta$, therefore by substitution,

$$dx=\frac{d\theta}{c\cos^2\theta\{F(\theta)-K\}}$$

$$dy=\frac{\tan\theta\, d\theta}{c\cos^2\theta\{F(\theta)-K\}} \qquad (25)$$

These expressions are not susceptible of integration in finite terms; but as x and y have the forms $x=\int\psi(\theta)d\theta$ and $y=\int\psi'(\theta)d\theta$ (ψ and ψ' denoting known functions of θ) and as θ varies within given limits, from $\theta=A$ to $\theta=0$ in the ascending branch of the curve, and from $\theta=0$ to $\theta=90°$ in the descending branch, the problem is thus brought within the method of quadratures; that is to say, it depends on finding the areas of two curves, of which the ordinates are respectively $\psi(\theta)$ and $\psi'(\theta)$, corresponding to the abscis θ. Hence x and y may be found for given values of θ, and consequently any number of points may be found in the trajectory.

Instead of employing the equations (25), the curve may be constructed by means of equation (24), which is the method followed by Euler. That equation gives $e^{2cz}=2ch\cos^2 A\{K-F(\theta)\}$, whence we have

$$\log z=\frac{1}{2c}\log\left[2ch\cos^2 A\{K-F(\theta)\}\right].$$

Now, if θ be the angle which the tangent makes with the horizon at the point P of the curve, and z the length of the arc AP, and if at the point p at a small but finite distance from P, the angle becomes $\theta-\omega$, and the arc $z+\Delta z$, then if the formula be computed for a given value of θ, (for example 30°), and also for $\theta-\omega$ (suppose 25°), the difference between the two resulting numbers will give the length of the arc $Pp=\Delta z$. Thus we can find the values of a great number of small portions, and the inclinations of the two tangents at their extremities. We can also assign to each of these portions its proportion of the abscis and ordinate, without having recourse to the values of x and y; for the portion of the abscis corresponding to Pp or Δz being Δx, and $\theta-\frac{1}{2}\omega$ being the inclination of its middle point to the horizon, we have $\Delta x=\Delta z\cos(\theta-\frac{1}{2}\omega)$; and in like manner $\Delta y=\Delta z\sin(\theta-\frac{1}{2}\omega)$. By adding all these portions together, the co-ordinates will be obtained, and consequently the points of the curve from $\theta=A$ to $\theta=0$, or through the ascending branch from A to the vertex. Near the point of projection, the variation of the length of the arc is much greater than that of the angle θ, and therefore at the commencement it may be necessary to compute θ for each degree, that is, to assume $\omega=1°$; but a sufficiently near approximation will be obtained by taking intervals of 5°, or making $\omega=5°$ throughout the rest of the curve. It will be observed that the logarithms of the formulæ are hyperbolic; and therefore the logarithms of the common tables must be divided by the modulus M.

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We have still to find expressions for the time and velocity. From equation (19) $\frac{d\theta}{\cos^2\theta}dx=-gdt^2$. Multiplying by c, and substituting for dx, its value given by the first of the equations (25), this becomes $\frac{d\theta^2}{\cos^4\theta\{F(\theta)-K\}}=-cgdt^2$, whence, transposing and extracting the root,

$$\sqrt{cg}\,.\,dt=\frac{d\theta}{\cos^2\theta\{F(\theta)-K\}^{\frac{1}{2}}}. \qquad (26)$$

In this equation the radical must be regarded as a positive quantity, because when the time t increases, the angle θ diminishes.

For the velocity we have from (19) $\frac{dx}{dt}=-g\cos^2\theta\frac{dt}{d\theta}$.

But $dx=dz\cos\theta$, therefore $v=\frac{dz}{dt}=-g\cos\theta\frac{dt}{d\theta}$, and

$v^2=g^2\cos^2\theta\frac{dt^2}{d\theta^2}$. Substituting in this equation the value of $\frac{dt^2}{d\theta^2}$ given by (26), we have

$$v^2=\frac{g}{c\cos^2\theta\{K-F(\theta)\}}. \qquad (27)$$

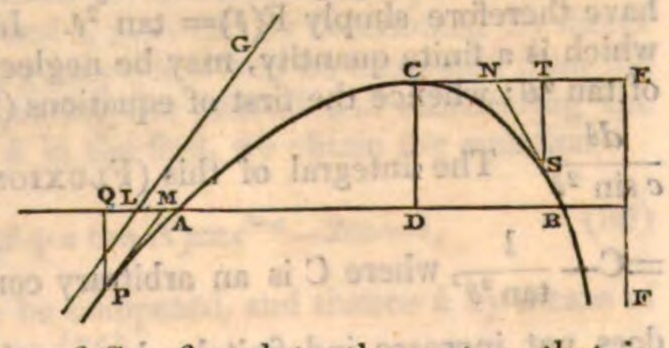
As the vertex, $\theta=0$, and $\cos^2\theta=1$; therefore, assuming u to denote the velocity at the vertex, the equation becomes $u^2=g\div cK$; or, since $c=g\div b^2$, $u^2=b^2\div K$; whence it appears that K is the ratio of the square of the terminal velocity to the square of the velocity in the vertex.

If there were no resistance, the smallest velocity would be at the vertex, and beyond the vertex it would immediately increase by the action of gravity conspiring (in a small degree, however) with the motion of the body. But in a resisting medium the velocity at the vertex is diminished by a quantity to which the acceleration of gravity in that point bears no assignable proportion. It is therefore diminished upon the whole, and the point of smallest velocity is a little way beyond the vertex. It is not material for our present purpose to determine the exact position of that point.

By means of the expressions which have now been found, we are enabled to compute for every value of θ, from the point of projection where $\theta=A$, to the vertex where $\theta=0$, the corresponding point of the trajectory, the time which the projectile takes to arrive at that point, and the velocity with which it is then moving. We now proceed to consider the motion in the descending branch.

Let the origin of the co-ordinates (fig. 4.) be transferred to the vertex C; let CE be horizontal, CD vertical, S a point in the descending branch, SN a tangent at S, meeting CE in N, and ST parallel to CD. Also let x' and y' be the co-ordinates of S referred to the vertex, that is,

Fig. 4.



Projectiles. make $x'=CT$, $y'=ST$, and suppose the co-ordinates of the vertex to be p and q, namely $AD=p$, $CD=q$. Then the co-ordinates of S referred to A being always represented by x and y, we have

$$x=p+x',\ y=q-y',\ dx=dx',\ dy=-dy'.$$

Now it will be observed, that in the descending branch the angle θ is negative, or that $ENS=-\theta$; whence the first of the two equations in (25) becomes in the present case

$$dx'=\frac{-d\theta}{c\cos^2\theta\left\{F(-\theta)-K\right\}}.$$

But from (23), $F(-\theta)=\frac{-\sin\theta}{\cos^2\theta}+\log\tan(45°-\frac{1}{2}\theta)$; and

$\tan(45°-\frac{1}{2}\theta)=\cot(45+\frac{1}{2}\theta)=\frac{1}{\tan(45°+\frac{1}{2}\theta)}$; whence

$\log\tan(45°-\frac{1}{2}\theta)=-\log\tan(45°+\frac{1}{2}\theta)$, and consequently $F(-\theta)=-F(\theta)$. Equations (25) therefore become

$$dx'=\frac{d\theta}{c\cos^2\theta\left\{K+F(\theta)\right\}}$$

$$dy'=\frac{-\tan\theta\,d\theta}{c\cos^2\theta\left\{K+F(\theta)\right\}}. \qquad (28)$$

In like manner the equation (24) becomes in this case

$$e^{2cz'}=2ch\cos^2A\left\{K+F(\theta)\right\},$$

z' being the arc counted from the vertex; and the expressions for the time and velocity become respectively

$$\sqrt{cg}.dt=\frac{d\theta}{\cos^2\theta\left\{K+F(\theta)\right\}^{\frac{1}{2}}};\ v^2=\frac{g}{c\cos^2\theta\left\{K+F(\theta)\right\}}. \qquad (29)$$

All these expressions are computed for successive values of θ from $\theta=0$; and a sufficient approximation will be obtained by assuming θ to vary by intervals of 5°. The ascending and descending branches of the trajectory are thus computed independently, as if they belonged to different curves.

In the descending branch the angle $\theta=ENS$ continually increases with the distance of the point S from C, until it becomes a right angle, which is its limiting value. But x' can only increase to a certain magnitude, which it would attain when S is at an infinite distance, and consequently this branch of the curve has an asymptote, which is perpendicular to the horizon. To prove this, let the factor $K+F(\theta)$ be developed, and let us consider what it becomes when θ approaches its limit. We have $F(\theta)=\frac{\sin\theta}{\cos^2\theta}+\log.\tan(45°+\frac{1}{2}\theta)$. Now when θ approaches very nearly to a right angle, $\sin\theta=1$, and $\frac{1}{\cos^2\theta}\ (=1+\tan^2\theta)$ $=\tan^2\theta$; therefore $\frac{\sin\theta}{\cos^2\theta}=\tan^2\theta$. With respect to the second term, when θ is nearly $=90°$, then $\tan(45°+\frac{1}{2}\theta)$ becomes very large, and nearly equal to $\tan\theta$; but the logarithm of a very large number may be neglected as insensible in comparison of the square of the number, we have therefore simply $F(\theta)=\tan^2\theta$. In like manner, K, which is a finite quantity, may be neglected in comparison of $\tan^2\theta$; whence the first of equations (28) becomes $dx'=\frac{d\theta}{c\sin^2\theta}$. The integral of this (Fluxions, art. 153) is $x'=C-\frac{1}{\tan^2\theta}$, where C is an arbitrary constant. Hence x' does not increase indefinitely, but as θ increases, it approaches nearer and nearer to a constant C, with which it coincides when θ is infinite. The constant C cannot be determined from this equation; but if we assume $k=\frac{1}{c}$ $\int_0^\infty\frac{d\theta}{\cos^2\theta\left\{K+F(\theta)\right\}}$, the value of k may be approximately computed by the method of quadratures. Suppose k to be determined, make $CE=k$, and draw through E the vertical EF, then EF is the asymptote of the descending branch of the curve.

Projectiles.

The terminal velocity b may be determined from equation (27). On changing θ into $-\theta$ in that equation, and supposing θ to become a right angle, we have $b^2=\frac{g}{c\sin^2\theta}$ $=\frac{g}{c}$; whence $b=\sqrt{\frac{g}{c}}$, which agrees with the assumed value of c, namely $c=g\div b^2$.

Although the motion commences at the point A, the curve may be supposed to be continued infinitely below the line AB. This branch of the curve has also an asymptote, the position of which it is important to determine. If in the equation (23)

$$e^{2cz}-1=2ch\cos^2A\left\{F(A)-F(\theta)\right\},$$

we suppose z to be negative and infinite, and assume B to denote the value of θ when z is infinite, we shall have

$$F(B)=\frac{1}{2ch\cos^2A}+F(A), \qquad (30)$$

whence from equation (22), $F(B)=K$. Substituting this value of K in the two equations (25), and observing, that for any point in this branch of the curve below AB, x and y are both negative, we have

$$dx=\frac{d\theta}{c\cos^2\theta\left\{F(B)-F(\theta)\right\}},\ dy=\frac{\tan\theta d\theta}{c\cos^2\theta\left\{F(B)-F(\theta)\right\}}.$$

Now let P (fig. 4.) be a point in the curve, PM a tangent at P, meeting AB in M, let AQ and PQ be the co-ordinates of P, and make $AM=l$. We have then $l=AQ-MQ$ $=x-\frac{y}{\tan\theta}$. Suppose now the point P at an infinite distance, then θ becomes B, the tangent MP becomes an asymptote, and $l=x-\frac{y}{\tan B}$. Hence $dl=dx-\frac{dy}{\tan B}$; and therefore, on substituting the above values of dx and dy, we get

$$dl=\frac{(\tan B-\tan\theta)d\theta}{c\tan B\cos^2\theta\left\{F(B)-F(\theta)\right\}}.$$

The integral of this expression from $\theta=A$ to $\theta=B$ will give the distance of the asymptote from the point. Let the definite integral be denoted by λ, that is, let

$$\lambda=\frac{1}{c\tan B}\int_A^B\frac{(\tan B-\tan\theta)d\theta}{\cos^2\theta\left\{FB-F(\theta)\right\}}, \qquad (31)$$

then λ may be computed by the method of quadratures. If we then take on the prolongation of AB, AL equal to λ, and draw through L the line LG, making with AB an angle $=B$, then LG will be the asymptote of the branch AC. The whole curve will then lie between the two asymptotes, which are inclined to each other in an angle $=90°-B$.

Such, then, is the process by which the form and magnitude of the trajectory, and the motion in it may be determined. But it does not yet appear how this is to be appli-

Projectiles. ed to any question in practical artillery. By means of the preceding formulæ, we are enabled to compute the motion from any point in the ascending branch to the vertex, where the motion becomes horizontal, and the motion from the vertex to a point in the descending branch, where the motion has acquired another determinate direction; the constants which enter into the formulæ being c and K, of which c ($=g \div b^2$) depends on the terminal velocity, and therefore on the nature of the projectile and the ratio of its density to that of the air; and K on the initial velocity, the terminal velocity, and the angle of elevation. We have also shewn that K denotes the ratio of the square of the terminal velocity to the square of the velocity in the vertex; therefore the terminal velocity and velocity in the vertex may be regarded as the two constants of the formulæ. The mode in which the formulæ are applied to the solution of the usual question, namely, to find the motion of a ball projected in a certain direction, with a certain velocity, is as follows: Suppose a trajectory, computed for a particular terminal velocity b, and for a particular velocity at the vertex, and that the velocity at that point of the ascending branch where the inclination of the tangent is 30° is 900 feet per second. Then, we are certain, that if a ball, whose terminal velocity is b, be projected with the velocity of 900 feet per second, and an elevation of 30°, it will describe this very trajectory, and the velocity and time corresponding to every point will be such as is here determined.

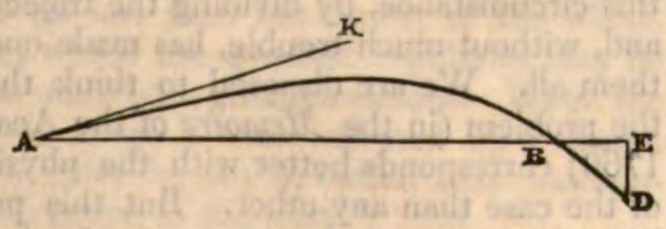
Now this trajectory will, in respect to form, answer an infinity of cases: for its characteristic is the proportion of the velocity in the vertex to the terminal velocity. If, therefore, we compute the trajectories for a sufficient variety of these proportions, we shall find a trajectory that will nearly correspond to any case that can be proposed: and an approximation sufficiently exact will be had by taking a proportional medium between the two trajectories which come nearest to the case proposed.

Accordingly, a set of tables or trajectories have been computed by the English translator of Euler's *Commentary on Robins's Gunnery*. They are in number 18, distinguished by the position of the assymptote of the ascending branch. This is given for 5°, 10°, 15°, &c. to 85°, and the whole trajectory is computed as far as it can ever be supposed to extend in practice.

Since the path of a projectile is much less incurvated, and more rapid in the ascending than in the descending branch, and the difference is so much the more remarkable in great velocities, it must follow, that the range on a horizontal or inclined plane depends most on the ascending branch: therefore the greatest range will not be made with that elevation which bisects the angle of position, but with a lower elevation; and the deviation from the bisecting elevation will be greater as the initial velocities are greater. It is difficult to frame a rule for determining with much precision, the elevation which gives the greatest range.

When the angle of elevation is very small, and consequently the path of the projectile nearly horizontal, the formulæ admit of simplifications which it is important to consider. Suppose KAB (fig. 5.) the angle of elevation to be small, then θ, the angle which the tangent at any other point of the trajectory makes with AB, will be very small, and $\sin\theta$ and $\tan\theta$ will be very small fractions. Suppose the angle so small that $\tan^2\theta$ may be neglected as insensible; then $\cos\theta$ may be regarded as unit, and the equation $dx = dz\cos\theta$ gives $dx = dz$. Hence $x = z$ and equation (20) becomes

Fig. 5.



$$\frac{d\theta}{\cos^2\theta} = -\frac{dx}{2h\cos^2 A}e^{2cx}, \qquad (32)$$

Projectiles.

the integral of which, since $d.\, e^{2cx} = 2c\, e^{2cx}dx$, is

$$\tan\theta = -\frac{1}{4ch\cos^2 A}e^{2cx} + C.$$

To determine the constant we suppose $x = 0$, in which case $\theta = A$, and we have

$$\tan A = -\frac{1}{4ch\cos^2 A} + C,$$

whence the complete integral is

$$\tan\theta = \tan A - \frac{1}{4ch\cos^2 A}\left(e^{2cx} - 1\right).$$

Multiplying both sides of this equation by dx, observing that $dy = dx\tan\theta$, and integrating, we get

$$y = \tan A\, x - \frac{1}{4ch\cos^2 A}\left(\frac{1}{2c}e^{2cx} - x\right) + C.$$

But when $x = 0$, $y = 0$, and this equation becomes

$$0 = \frac{1}{8c^2h\cos^2 A} + C;$$

therefore the complete integral is

$$y = x\tan A - \frac{1}{8c^2h\cos^2 A}(e^{2cx} - 2cx - 1), \qquad (33)$$

which gives an approximate equation of the trajectory between the co-ordinates x and y.

To determine the time corresponding to the horizontal distance x, we have from equation (19) $\frac{d\theta}{\cos^2\theta}dx = -gdt^2$, whence by reason of (32) $dt^2 = \frac{1}{2gh\cos^2 A}e^{2cx}dx^2$, and consequently

$$dt = \frac{1}{\sqrt{(2gh)}\cos A}e^{cx}dx.$$

Integrating this expression, and determining the constant so that $x = 0$ when $t = 0$, we get

$$t = \frac{1}{c\cos A\sqrt{(2gh)}}(e^{cx} - 1.) \qquad (34)$$

The two equations (33) and (34) may be employed for the purpose of determining the co-efficient c of the resistance on the terminal velocity which depends on it, from experiments. Suppose the trajectory to be continued to D, a small distance below the horizontal line AB. For this point of the curve the approximation may still be regarded as sufficiently accurate. Let DE be vertical, make AE $= a$, ED $= \beta$, and the time in which the projectile passes from A to D $= \tau$. Substituting these values of x, y, and t in the equations (33) and (34), making $\cos A = 1$, because A is by supposition a very small angle, and observing that since D is below AB, y must be taken as negative, the two equations give

$$8hc^2(\beta + a\tan A) = e^{2ca} - 2ca - 1,$$
$$\tau c\sqrt{(2gh)} = e^{ca} - 1. \qquad (35)$$

Now, of the quantities involved in these equations, g and $\tan A$ are known, and a, β, τ, can be determined by direct experiments, leaving only c and h to be computed from the equations. On squaring the second, and substituting the resulting value of h in the first, we obtain the equation

$$\frac{(4e^{ca} - 1)^2}{\tau^2 g}(\beta + a\tan A) = e^{2ca} - 2ca - 1, \qquad (36)$$

from which c may be computed, and thence h by means of one of the equations (35).

Projectiles. Of the quantities which enter into the equations (35) and which are to be found from experiment, that which can be determined with the least certainty is τ, the time of flight. This, however, may be eliminated by varying the experiment. Suppose the projectile to be discharged at a different height above the ground, for instance the top of a tower, (the angle of elevation A, and the initial velocity remaining the same,) and let a, β, become respectively a', β', we have then, from the first of equations (35),

$$8hc^2(\beta' + a' \tan A) = e^{2ca'} - 2ca' - 1$$
$$8hc^2(\beta + a \tan A) = e^{2ca} - 2ca - 1,$$

whence

$$(\beta' + a' \tan A)(e^{2cz} - 2ca - 1) = (\beta + a \tan A)(e^{2ca'} - 2ca' - 1)$$

an equation from which the value of c may be computed when a, β, and also a' β' are determined from experiments.

The solution which we have now given of this celebrated problem is exact in principle, and the application of it by no means difficult or even operose. But let us see what advantage we are likely to derive from it.

In the first place, it is very limited in its application. There are few circumstances of general coincidence, and almost every case requires an appropriate calculus. Perhaps the only general rules are the two following:

1. Balls of equal density, projected with the same elevation, and with velocities which are as the square roots of their diameters, will describe similar curves. This is evident, because, in this case, the resistance will be in the ratio of their quantities of motion. Therefore all the homologous lines of the motion will be in the proportion of the diameters.

2. If the initial velocities of balls projected with the same elevation are in the inverse subduplicate ratio of the whole resistances, the ranges, and all the homologous lines of their track, will be inversely as those resistances.

These theorems are of considerable use; for by means of a proper series of experiments on one ball projected with different elevations and velocities, tables may be constructed which give the motions of an infinity of others.

But when we take a retrospective view of what we have done, and consider the conditions which were assumed in the solution of the problem, we shall find that much yet remains before it can be rendered of great practical use. The resistance is all along supposed to be in the duplicate ratio of the velocity; but even theory points out many causes of deviation from this law, such as the pressure and condensation of the air, in the case of very swift motions; and Mr. Robins's experiments are sufficient to show us that the deviations must be exceedingly great in such cases. Euler and all subsequent writers have allowed that it may be three times greater, even in cases which frequently occur; and Euler gives a rule for ascertaining with tolerable accuracy what this increase and the whole resistance may amount to. Let H be the height of a column of air whose weight is equivalent to the resistance taken, in the duplicate ratio of the velocity. The whole resistance will be expressed by $H + \frac{H^2}{28845}$. This number 28845 is the height in feet of a column of air whose weight balances its elasticity. We shall not at present call in question his reason for assigning this precise addition. They are rather reasons of arithmetical conveniency than of physical import. It is enough to observe, that if this measure of the resistance is introduced into the process of investigation, it is totally changed; and it is not too much to say, that with this complication it requires the knowledge and address of a Euler to make even a partial and very limited approximation to a solution. Any law of the resistance, therefore, which is more complicated than what Bernoulli has assumed, namely, that of a simple power of the velocity, must be abandoned on account of the intricacy of the calculations; and mathematicians have attempted to avoid the error arising from the assumption of the duplicate ratio of the velocity, either by supposing the resistance throughout the whole trajectory to be greater than what it is in general, or they have divided the trajectory into different portions, and assigned different resistances to each, which vary, through the whole of that portion, in the duplicate ratio of the velocities. In this manner they make up a trajectory and motion which correspond, in some tolerable degree, not with an accurate theory, but with a series of experiments. For, in the first place, every theoretical computation that we make, proceeds on a supposed initial velocity; and this cannot be ascertained with any thing approaching to precision, by any theory of the action of gunpowder that we are yet possessed of. In the next place, our theories of the resisting power of the air are entirely established on the experiments on the flights of shot and shells, and are corrected and amended till they tally with the most approved experiments we can find. We do not learn the ranges of a gun by theory, but the theory by the range of the gun. Now the variety and irregularity of all the experiments which are appealed to are so great, and the acknowledged difference between the resistance to slow and swift motions is also so great, that there is hardly any supposition which can be made concerning the resistance, that will not agree in its results with many of those experiments. It appears from the experiments of Dr. Hutton of Woolwich, in 1784, 1785, and 1786, that the shots frequently deviated to the right or left of their intended track 200, 300, and sometimes 400 yards. This deviation was quite accidental and anomalous, and there can be no doubt but that the shot deviated from its intended and *supposed* elevation as much as it deviated from the intended vertical plane, and this without any opportunity of measuring or discovering the deviation. Now, when we have the whole ranges from one to three to choose among for our measure of resistance, it is evident that the confirmations which have been drawn from the ranges of shot are but feeble arguments for the truth of any opinion. Mr. Robins finds his measures fully confirmed by experiments made at Metz and Minorca. Mr. Muller finds the same. Yet Mr. Robins's measures, both of the initial velocity and of the resistance, are at least treble of Mr. Muller's; but by compensation they give the same results. The Chevalier Borda has adduced the very same experiments in support of his theory, in which he abides by the Newtonian measure of the resistance, which is about $\frac{1}{3}$ of Mr. Robins's, and about $\frac{2}{3}$ of Muller's. From all this we may conclude, that we have as yet a very uncertain and imperfect knowledge of the law and the measure of the air's resistance.

There is another essential defect in the conditions assumed in the solution. The density of the air is supposed uniform; whereas we are certain that it is less by one-fifth or one-sixth towards the vertex of the curve, in many cases which frequently occur, than it is at the beginning and end of the flight. This is another latitude given to authors in their assumptions of the air's resistance. Borda has, with considerable ingenuity, accommodated his investigation to this circumstance, by dividing the trajectory into portions, and, without much trouble, has made one equation answer them all. We are disposed to think that his solution of the problem (in the *Memoirs* of the Academy of Paris for 1769) corresponds better with the physical circumstances of the case than any other. But this process is there delivered in too concise a manner to be intelligible to a person not perfectly familiar with all the resources of modern analysis.

After all, the practical artillerist must rely chiefly on the records of experiments contained in the books of practice at the academies, or those made in a more public manner.

Projectiles. Even a perfect theory of the air's resistance can do him little service, unless the force of gunpowder were uniform. This is far from being the case even in the same powder. A few hours of a damp day will make a greater difference than occurs in any theory; and, in service, it is only by trial that everything is performed. If the first shell fall very much short of the mark, a little more powder is added; and in cannonading, the correction is made by varying the elevation.

The experiments of Mr. Robins and Dr. Hutton show, in the most incontrovertible manner, that the resistance to a motion exceeding 1100 feet in a second, is almost *three times* greater than in the duplicate ratio of the resistance to moderate velocities. Euler's translator, in his comparison of the author's trajectories with experiment, supposes it to be *no* greater. Yet the coincidence is very great. The same may be said of Borda's. Nay, the same may be said of Mr. Robins's own practical rules: for he assumes the quantity which represents the height due to the terminal velocity, almost double of what these authors do, and yet his rules are confirmed by practice.

But it must not be inferred from all this, that the physical theory is of no use to the practical artillerist. It plainly shows him the impropriety of giving the projectile an enormous velocity. This velocity is of no effect after 200 or 300 yards at farthest, because it is so rapidly reduced by the prodigious resistance of the air. Mr. Robins has deduced several practical maxims of the greatest importance from what we already know of this subject, and which could hardly have been even conjectured without this knowledge. See GUNNERY.

It must also be acknowledged, that this branch of physical science is highly interesting to the philosopher; nor should he despair of carrying it to a greater perfection. The defects arise almost entirely from our ignorance of the law of variation of the air's resistance. Experiments may be contrived much more conducive to our information here than those commonly resorted to. The oblique flights of projectiles are, as we have seen, of very complicated investigation, and ill fitted for instructing us; but numerous and well contrived experiments on the perpendicular ascents are of great simplicity, being affected by nothing but the air's resistance.

We shall conclude this article, by giving two tables, computed from the principles established above, and which serve to bring into one point of view the chief circumstances of the motion in a resisting medium. Although the result of much calculation, as any person who considers the subject will readily see, they must not be considered as offering any very accurate results; or that, in comparison with one or two experiments, the differences shall not be considerable. Let any person peruse the published registers of experiments which have been made with every attention, and he will see such enormous irregularities, that all expectations of perfect agreement with them must cease. In the experiments at Woolwich in 1785, which were continued for several days, not only do the experiments of one day differ among themselves, but the mean of all the experiments of one day differs from the mean of all the experiments of another no less than one-fourth of the whole. The experiments in which the greatest regularity may be expected, are those made with great elevations. When the elevation is small, the range is more affected by a change of velocity, and still more by any deviation from the supposed or intented direction of the shot.

The first table shows the distance in yards to which a ball projected with the velocity of 1600 feet in a second will go, before its velocity is reduced one-tenth, and the distance at which it drops 16 feet from the line of its direction. This table is calculated by the resistance observed in Mr. Robins's experiments. The first column is the weight of the ball in pounds. The second column remains the same whatever be the initial velocity; but the third column depends on the velocity. It is here given for the velocity which is very usual in military service, and its use is to assist us in directing the gun to the mark. If the mark at which a ball of 24 pounds is directed is 474 yards distant, the axis of the piece must be pointed 16 feet higher than the mark. These deflections from the line of direction are nearly as the squares of the distances.

I.	II.	III.
2	92	420
4	121	428
9	159	456
18	200	470
32	272	479

The next table contains the ranges in yards of a 24-pound shot, projected at an elevation of 45°, with the different velocities in feet per second, expressed in the first column. The second column contains the distances to which the ball would go *in vacuo* in a horizontal plane; and the third contains the distances to which it will go through the air. The fourth column is added, to shew the height to which it rises in the air; and the fifth shows the ranges corrected for the diminution of the air's density as the bullet ascends, and may therefore be called the *corrected range*.

I.	II.	III.	IV.	V.
200	416	349	106	360
400	1664	1121	338	1150
600	3740	1812	606	1859
800	6649	2373	866	2435
1000	10300	2845	1138	2919
1200	14961	3259	1378	3343
1400	20364	3640	1606	3734
1600	26597	3950	1814	4050
1800	33663	4235	1992	4345
2000	41559	4494	2168	4610
2200	50286	4720	2348	4842
2400	59846	4917	2460	5044
2600	70235	5106	2630	5238
2800	81456	5293	2760	5430
3000	93465	5455	2862	5596

The initial velocities can never be pushed as far as they have been calculated for in this table; but we mean it for a table of more extensive use than appears at first sight. Recollect, that while the proportion of the velocity at the vertex to the terminal velocity remains the same, the curves will be similar; therefore, if the initial velocities are as the square roots of the diameters of the balls, they will describe similar curves, and the ranges will be as the diameters of the balls.

Let it be required, for example, to find the range of a 12-pound shot, projected at an elevation of 45°, with the velocity 1500; suppose the diameter of the twelve-pounder to be d, and that of the twenty-four-pounder D; and let the velocities be v and V: Then say, $\sqrt{d} : \sqrt{D} = 1500$: a fourth proportional V. If the twenty-four-pounder be projected with the velocity V, it will describe a curve similar to that described by the twelve-pounder, having the initial velocity 1500. Therefore find (by interpolation) the range of the twenty-four-pounder, having the initial velocity V. Call this R. Then $D : d = R : r$, the range of the twelve-pounder which was wanted, and which, assuming the diameters of

Projection. the balls to be 4·45 and 5·61 inches, respectively, will be found 3312.

This table shews the immense difference between the motions through the air and in a void. It shews also that the ranges through the air, instead of increasing in the duplicate ratio of the initial velocities, really increase slower than those velocities in all cases of military service; and in the most usual cases, viz. from 800 to 1600, they increase nearly as the square roots of tbe velocities.

A set of similar tables, made for different elevations, would almost complete what can be done by theory, and would be much more expeditious in their use than Mr. Euler's *Trajectories*, computed with great labour by his English translator.

The same table may also serve for computing the ranges of bomb-shells. We have only to find what must be the initial velocity of the twenty-four-pound shot which corresponds to the proposed velocity of the shell. This must be deduced from the diameter and weight of the shell, by making the velocity of the twenty-four pounder such, that the ratio of its weight to the resistance may be the same as in the shell. Projection.

Dr. Hutton, in his *Mathematical Tracts* (vol. iii. p. 276), has given a similar table, deduced partly from theory and partly from experiment, but the numbers in the three last columns differ greatly from the above, particularly for the higher velocities. Thus, for the velocity of 1600 feet, Dr. Hutton's corrected range is 2264 yards, and the height to which the ball rises 650 yards, instead of 4050 and 1814, as in our table.

For further information on this subject, see GUNNERY; Robins's *Mathematical Tracts*; Brown's *True Principles of Gunnery*; Hutton's *Mathematical Tracts*; and for an example of the computation of a trajectory by the method of quadratures, Legendre's *Exercises de Calcul.* tome i. p. 330.

PROJECTION. Projection of the Sphere in *Astronomy* and *Geography* signifies in general a perspective representation of the surface of the sphere on a plane; and it is of various kinds according to the different positions of the eye and the plane of projection.

As the principles of the different projections commonly employed in the construction of maps and charts, and the method of applying them, have already been explained in the article GEOGRAPHY, (chap. iv.,) we shall merely give a general view of the subject in this place, referring the reader to the article just cited, for the details and demonstrations.

The simplest of all the projections is the *Orthographic*. Considered as a perspective delineation of the surface of the sphere, this supposes the eye to be placed at an infinite distance, so that all the rays coming from the different parts of the surface are parallel; and the *plane of projection*, or plane upon which the representation is made, is assumed to be perpendicular to the direction of the visual rays, and to pass through the centre of the sphere. The orthographic projection of any point is therefore the intersection of a perpendicular from that point with the plane of projection. When the object is to represent only a small portion of the surface of the sphere, situated near the *pole of projection*, or point in which the straight line from the eye to the centre of the sphere intersects the surface, this projection answers every purpose; but it is not so well adapted to the delineation of a whole hemisphere, or even a considerable portion of it; for the distances from the pole being represented by the sines of the arcs by which they are measured on the sphere, and as the sines of large arcs increase in a much smaller ratio than the arcs themselves, the map is necessarily crowded and distorted towards the extremities, and gives a very imperfect representation of the objects delineated.

The principal properties of the orthographic projection are, 1st, That all the great circles of the sphere, the planes of which pass through the eye, are represented by straight lines: 2d, That all circles, (they can only be small circles) the planes of which are perpendicular to the line of sight, are represented by circles: 3d. That all other circles, whether large or small, being seen obliquely, are represented by ellipses. This method of projection was known to the ancient astronomers, and employed by them in the construction of the *Analemma*, a sort of instrument for the graphical solution of various problems of the sphere, on which Ptolemy wrote a treatise, which has been preserved through the medium of an Arabic version, and of which a Latin translation was published by Commandine at Rome in 1562. The orthographic projection is conveniently used for various astronomical purposes, such as the geometrical delineation of eclipses, transits, and occultations; and it has numerous applications in the arts, the plans and sections by which artificers execute their constructions, being merely orthographical projections of the things to be constructed.

In the *Stereographic* projection the eye is supposed to be situated at the surface of the sphere, and the plane of projection is the plane of the great circle, at the pole of which the eye is placed. The hemisphere which is projected, is that which is opposite to the eye, and consequently the sphere must be supposed transparent, in order that the different points of its surface may be visible. According to the testimony of two ancient authors, Synesius and Proclus, this projection was invented by Hipparchus. It was called the *Planisphere*, on which also there is a treatise by Ptolemy, preserved through the Arabic. The term *Stereographia* (derived from στερεος, solid, because it results from the intersection of two solids, the sphere and the cone) was, according to Delambre, first applied to it by the Jesuit Aguilon in a *Treatise on Optics*, published at Antwerp in 1613. The astrolabe, an instrument formerly much in use for the graphical solution of astronomical problems connected with the diurnal motion, was constituted on this projection.

The two principal properties of the stereographic projection are, 1st, That all circles on the sphere which do not pass through the eye, whether great or small, are projected into circles; and, 2d, That the circles of projection intersect each other under the same angles as their corresponding circles on the sphere. The first of these properties is of great importance, by reason of the facility which it affords for the construction of maps. It is demonstrated in the planisphere of Ptolemy for all the particular cases that occur in the projections there described; and although the general proposition is not formally mentioned, it can scarcely be supposed to have been unknown to him, as his demonstrations are easily rendered applicable to every case. It is, indeed, an almost obvious consequence of a property demonstrated by Apollonius relative to the subcontrary sections of the oblique cone. The demonstration of Ptolemy for the particular cases is, however, entirely independent of the theorem of Apollonius. Delambre (*Astronomie Ancienne*, tom. ii. p. 456) states, that the oldest work in which he has met with the enunciation of the general property is the *Planisphere* of Jordanus, published with some other astronomical tracts, at Toulouse in 1544. It may be remarked, that Jordanus, instead of projecting the hemisphere on the plane of the equator, chooses for the plane of projection, the plane touching the sphere at the north pole. The property of the equality of angles, which is also very curious and important, appears to be of modern discovery,

Projection. but the author of it is not certainly known. Delambre (*Astronomie*, tom. iii. p. 674) says, he has searched for it in vain in the large treatise of Clavius, in that of Stoflerinus, and in Bion; and (*Histoire de l'Astronomie au Dix-Huitième Siècle*, p. 88,) that the oldest demonstration of it known to him is in *Leadbetter's Astronomy*, London, 1728. It had, however, been previously demonstrated by Dr. Halley in 1696, in No. 219 of the *Philosophical Transactions*, in which he attributes the first discovery of the proposition to Demoivre or Hook.

As the surface of a sphere is equal to four times the area of one of its great circles, it follows that in the stereographic projection on the plane of a great circle, the surface of the hemisphere is reduced to one-half of its original dimensions. This would be no defect, if the reduction were uniform; which, however, is far from being the case; for at the centre, the linear dimensions are reduced to one-half, and consequently the superficial to one-fourth; and the reduction becomes less and less towards the extremities of the map. Any portion of the upper hemisphere projected in this way would be enlarged. Hence there is little resemblance between a given portion of the spherical surface and its representation, which is the great defect of the projection. In maps of the stars, for which it is most frequently employed, there is also an inconveniency in the difficulty of finding the places of particular stars, for three or more objects, which in the apparent heavens are situated in the same straight line, are placed in the map on the circumference of a circle which is not represented. Nevertheless, the projection answers conveniently enough all the purposes, for which a map is required by the astronomer.

In the *Gnomonic* or *Central* projection, the eye is supposed to be placed at the centre of the sphere, and the plane of projection is a plane touching the sphere at any point assumed at pleasure. The point of contact is called the *principal point;* the projection of all other points are at the extremities of the tangents of the arcs intercepted between them and the principal point, and the tangents make with each other angles equal to those in which their arcs intersect at the pole. This projection is also described by Ptolemy in the *Analemma*, (Delambre, *Astr. Ancienne*, tom. ii. p. 486); but as the Greeks had no idea of the trigonometrical tangents, the polar distances are in that work expressed by the ratios of the sines to the cosines of the arcs. As the tangents of arcs exceeding 45° increase very rapidly, and become infinite for arcs of 90°, the projection cannot be employed for a whole hemisphere. The celestial maps published by the Society for the Diffusion of Useful Knowledge, are projected in this manner, and the surface embraced is one-sixth of the whole sphere, or the sphere is projected on the six sides of its circumscribing cube. For a map of the stars this projection possesses some advantage over the stereographic. All stars which appear in the same straight line in the heavens, are projected in the same straight line, so that their places can be readily found on the map; and from the position of the eye at the centre of the sphere, the appearance of the heavens is better preserved. The map is necessarily distorted in some degree near the extremities and corners, but not to so great an extent as to render it a bad representation. Besides, the distortion is equal for lines equally distant from the centre, and there is no angular distortion with respect to lines which pass through the centre of the map. This projection is particularly applicable to the construction of sun-dials and gnomons, whence its name.

The three kinds of projection now described, are chiefly employed in the construction of celestial maps; but for the purpose of representing portions of the earth's surface, the *Globular projection* is frequently had recourse to. This may be considered as a modification of the stereographic, or in a manner intermediate between the stereographic and orthographic. In the orthographic, the proportion of the Projection. parts of the projection to the parts on the sphere which they represent, decreases from the centre to the circumference of the projection; in the stereographic the projection increases; and as in the first case the eye is supposed at an infinite distance, and in the second, on the surface of the sphere, there must be some position at a finite distance from the surface, in which if the eye is placed, the proportion between the parts of the surface of the sphere and their representations, will be the same or nearly so, whether those parts be taken at the centre or circumference of the map. It is easy to shew that the height above the sphere at which this takes place is equal to the sine of 45 degrees, and therefore very nearly 71-hundredths of the radius. This projection was first proposed by La Hire, in the *Memoirs* of the Academy of Sciences of Paris for 1701. It is employed in many cases, on account of the small change of configuration; but by the removal of the eye from the surface the characteristic advantages of the stereographic projection are lost.

Projections of the circles of the sphere on a plane, are easily found by the methods of the descriptive Geometry, by spherical Trigonometry, or common Algebra. Whatever be the situation of the eye, every circle on the sphere, unless its plane pass through the eye, forms the base of a cone, of which the eye is the apex; and the intersection of this cone with the plane of projection, gives the curve into which the circle is projected. Hence the curve is necessarily a conic section and its equation cannot exceed the second degree. On forming the general equation of the curve, and assigning a determinate position to the eye and the plane of projection, all the properties of the different kinds of projection, which are merely particular cases of the same general problem, are readily deduced.

Although it is convenient to employ the principles of perspective in representing the lines and circles of the sphere on a plane surface, there is nothing in the nature of the thing itself, (unless the map is to be regarded as a picture) which renders such a mode of proceeding necessary. The meridians and parallels may be represented on the map by any lines whatever, and the map will still be accurate, if the different points are laid down so as to have respectively the same relative positions with respect to those lines as the points represented have to the corresponding circles of latitude and longitude; for in this case, any point on the map can be referred to its proper place on the sphere, which is the essential condition of a correct map. In order, however, to render the problem determinate, the lines chosen to represent the meridians and parallels of the sphere must be such as satisfy certain conditions capable of being expressed by an algebraic equation. But these conditions may have no reference to perspective. Mercator's Chart is an example. In this chart the condition which determines the relative situations of the meridians and parallels is, that the rhumbs shall be straight lines, and make with each other the same angles as on the sphere. This condition determines the well known property of the chart, namely, that the degrees of longitude are all equal, while the degrees of latitude vary in the inverse ratio of the sines of their polar distances.

The theory of the construction of maps on this general principle, was first considered by Lambert, who, in the third volume of his *Beiträge zum Gebrauche der Mathematik*, &c., published at Berlin in 1772, undertook the solution of the problem to determine the nature and situation of the lines on the map representing the meridians and parallels, where the condition to be fulfilled is, that the angles formed by lines on the map shall be equal to the corresponding angles on the sphere. This condition is important; for it follows from the equality of the angles that any indefinitely small portion of the surface of the sphere, and its projec-

Projection ‖ Prolation.

tion on the map, are similar figures; and consequently that the representations of such parts differ from the original only in respect of magnitude. The same problem was considered by Euler in the *Petersburg Commentaries* for 1777, but neither of these illustrious geometers prosecuted the subject farther than to shew that the known properties of the stereographic projection, and Mercator's Chart, are comprehended in their general solution.

In the volume of the *Berlin Memoirs* for 1779, there are two memoirs by Lagrange on the same subject. In the first he gave a solution of the problem of Lambert, of which he shewed the stereographic projection to be only a particular case; and in the second, he undertook the more difficult task of determining the form which the arbitrary functions that enter into the general solution must have in order that the lines representing the meridians and parallels may be of a given nature.

The general problem of projection has been more recently considered by the celebrated Professor Gauss of Göttingen, in a memoir written in answer to a prize question proposed by the Academy of Sciences of Copenhagen. In this memoir the author, instead of confining himself to the particular case of the representation of a spherical surface on a plane, undertook the solution of the general problem; namely, to represent the parts of any given surface on any other given surface, subject to the condition that the differential elements of the first surface shall be similar to their representations on the second. Having determined the differential expressions of the co-ordinates of any point on the map, in terms of the co-ordinates of the corresponding point of the primitive surface, he applies the general solution to the particular cases of a plane surface projected on another plane, the surface of a cone on a plane, of a sphere and spheroid on a plane, and lastly, of an ellipsoid of revolution on the surface of a sphere. Gauss's memoir is published in No. 3 of Schumacher's *Abhandlungen*, and a translation of it in the *Philosophical Magazine* for August and September 1828. Considered in this general view, the theory of projection becomes an interesting and very difficult mathematical speculation; but it is one of which, it must be confessed, the results are of no great practical use.

PROJECTION, in *Perspective*, denotes the appearance or representation of an object on the perspective plane. The projection of a point is a point through which an optic ray passes from the objective point through the plane to the eye; or it is the point in which the plane cuts the optic ray; and hence may be easily conceived what is meant by the projection of a line, a plane, or a solid.

PROJECTION, in *Alchemy*, the casting of a certain imaginary powder, called *powder of projection*, into a crucible or other vessel full of some prepared metal or other matter, which is to be hereby presently transmuted into gold.

Powder of PROJECTION, or of the philosopher's stone, is a powder supposed to have the virtue of changing any quantity of an imperfect metal, as copper or lead, into a more perfect one, as silver or gold, by the admixture of a little quantity of the powder. The mark to which alchemists directed all their endeavours, was to discover this powder of projection.

PROJECTURE, in *Architecture*, the outjetting and prominence, or embossing, which the mouldings and other members have beyond the naked wall, column, or other part of the building.

PROLAPSUS, in *Surgery*, a prolapsion or falling out of any part of the body from its natural situation. Thus we say, *prolapsus intestini*, a prolapsion of the intestine, &c.

PROLATE, in *Geometry*, an epithet applied to a spheroid produced by the revolution of a semi-ellipsis about its larger diameter.

PROLATION, a musical term signifying a series of notes, ascending or descending, which are to be sung to one syllable. Anciently the word had a different musical meaning. Thus Morley, in his Introduction, page 14, tells us that prolation is the measuring of semibreves by minims, and is either greater or less. The greater prolation is when the semibreve contains three minims. The sign of this is ⊙ or ☾. The less prolation is when the semibreve contains only two minims. The sign of this is ○ or ☾. The old musicians called the ternary measure *perfect*, and the binary measure *imperfect*.

Prolegomena ‖ Prometheus.

PROLEGOMENA, in *Philology*, certain preparatory observations prefixed to a book or treatise, and containing something necessary for the reader to be apprised of, to enable him the better to understand the book, or to enter deeper into the science.

PROLEPSIS, a figure in *Rhetoric*, by which we anticipate or prevent what might be objected by the adversary.

PROLEPTIC, an epithet applied to a periodical disease which anticipates, or whose paroxysm returns sooner and sooner every time; as is frequently the case in agues.

PROLOGUE, in dramatic poetry, a discourse addressed to the audience before the drama or play begins. The original intention was to advertise the audience of the subject of the piece, and to prepare them to enter more easily into the action, and sometimes also to make an apology for the poet.

PROME, a city of the Birman empire, in the province of Ava, situated on the eastern bank of the Irrawaddy River, in a fertile plain between the hills and the river. It was the original and natural boundary of the Birman empire to the south, before conquest had extended its dominion beyond it. It was formerly surrounded by two walls, constructed partly of brick and partly of timber. It is composed of the *myo* or fort, being a common square stockade, resembling that of Rangoon, but much larger; and of two suburbs, the one lying to the east and the other to the west of it, along the banks of the river. The first contains two streets running parallel to each other and to the river. The houses are few and scattered; and the principal space is occupied by gardens, or rather by patches of ground planted with fruit or ornamental trees, or coarse esculent vegetables, such as gourds, pumpkins, and cucumbers, the whole overgrown with rank weeds, and without order or neatness. Prome is, according to Mr Crawford, a thriving place; and he estimates its population at 10,000. It carries on a very considerable trade in grain, oil, wax, ivory, iron, lead, flagstones, and timber. The ruins of the former city, which extend far beyond the modern town, contain the remains of a number of temples dedicated to Buddha. Adjacent to the town is a royal menagerie of elephants, consisting of two rows of lofty and well-built stables, in which these animals are lodged during the rains. Long. 95. E. Lat. 18. 50. N.

PROMETHEUS, the son of Japetus and Asia or Clymenë, was the brother of Atlas, Epimetheus, and Menœtius. He was a prince of Meconë (the ancient name of Sicyon in the Peloponnesus), if we may trust the legend told by Hesiod. It is said that the inhabitants were debating with the gods which part of the animal ought to be offered to them in sacrifice, and that Prometheus recommended that the flesh and best parts should be covered with the caul, whilst the bones were enveloped in fat. Jupiter was then requested to make choice of the part he preferred; and, being deceived by the trick of Prometheus, he selected the bones, which were ever afterwards offered upon his altar. Indignant at this proceeding, he deprived men of the use of fire; but Prometheus is said to have again outwitted him, and drawn down fire from heaven, which he presented to man. This is explained by supposing that Prometheus was the first who discovered that fire could be extracted from two pieces of wood rubbed together. By another tradition, we find him making a man of clay, into which he conveys

Prometheus || Pronunciation.

the fire he had stolen from heaven, and for this daring invasion of his privileges, Jupiter orders Vulcan to chain Prometheus on Mount Caucasus, where he was visited daily by an eagle, which fed on his liver. Here he is said to have remained thirty thousand years, until Hercules accidentally visited him whilst in search of the Gardens of the Hesperides. He pointed out the way to him, and from gratitude Hercules slew the eagle and released Prometheus. Another tradition represents him as having been released by Jupiter, in return for warning him against marrying Thetis, as it was fated that her son should be more illustrious than his father. He was the father of Deucalion by Clymenë or Pandora.

PROMETHEUS, in *Ancient Astronomy*, was the name of a constellation of the northern hemisphere, now called *Hercules Eugonasin*.

PROMISE, in ordinary cases, is a declaration of some intention to be put in execution; but in morals it is a solemn asseveration by which one pledges his veracity that he will perform, or cause to be performed, the thing which he undertakes. As such a declaration excites expectations in the minds of those to whom it is made, and to frustrate such expectations might arouse indignation, and be followed by consequences injurious to the person, the character, or the interest of him who made it, it becomes a matter of prudence in the promiser to keep his word. And, farther, since a certain degree of confidence is found necessary to the very existence of civil society, and others may have acted upon the faith of such promise, it is now not a matter of prudence only to keep one's word, but is a duty which every man owes to all who have spent their time, their money, or their labour, in consequence of those expectations which he has warranted them to entertain. It being, then, consonant to sound reason, necessary to the existence of civil society, and in general the interest of both the promiser and promisee, that the words of the promise should be fulfilled, it has become a maxim in morals, that a man is obliged to perform his promise. See MORAL PHILOSOPHY.

PROMONTORY, in *Geography*, a high point of land or rock projecting into the sea, and the extremity of which is called a *cape* or *headland*. See GEOGRAPHY.

PROMPTER, in the drama, an officer posted behind the scenes, whose business it is to watch attentively the actors speaking on the stage, in order to suggest and put them forward when at a stand, and correct them when at fault in their parts.

PROMULGATED, or PROMULGED, something published or proclaimed, and generally applied to a law, to denote the publishing or proclaiming it to the people.

PRONAOS, in ancient architecture, a porch to a church, palace, or other spacious building.

PRONOUN, PRONOMEN, in *Grammar*, a declinable part of speech, which, being put instead of a noun, points out some person or thing.

PRONUNCIATION, in *Grammar*, the manner of articulating or sounding the words of a language.

Pronunciation forms the most difficult part of written grammar, in as much as a book expressing itself to the eyes, in a manner that wholly concerns the ears, seems next akin to that of teaching the blind to distinguish colours. Hence it is that there is no part so defective in grammar as that of pronunciation; for as the writer has frequently no term whereby to give the reader an idea of the sound he would express, so, for want of such a term, he often substitutes a vicious and precarious one. To give a just idea of the pronunciation of a language, it seems necessary to fix, as nearly as possible, all the several sounds employed in the pronunciation of that language. Cicero tells us, that the pronunciation underwent several changes amongst the Romans; and indeed it is more precarious in the living languages, being in these subservient to fashion and usage.

PRONUNCIATION is also used to indicate the fifth and last part of rhetoric, which consists in varying and regulating the voice agreeably to the matter and words, so as most effectually to persuade and touch the hearers.

Pronunciation || Property.

PROOF, in *Law* and *Logic*, is that degree of evidence which carries conviction to the mind. It differs from demonstration, which is applicable only to those truths of which the contrary is inconceivable. It differs likewise from probability, which produces for the most part nothing more than opinion, whilst proof produces belief.

PROPERTIUS, SEXTUS AURELIUS, a celebrated elegiac poet, who flourished between 31–15 B. C. The exact date of his birth is uncertain; but Mr Clinton brings forward satisfactory reasons for believing that it was about the year 51 B. C., being thus fourteen years younger than Horace, and eight younger than Livy. The place of his birth has also been disputed; but he himself states that he was a native of Umbria, though whether of Merania, Ameria, Hispellum, or Assisium, is uncertain. He studied at Rome with the intention of devoting himself to the bar; but his love of poetry seduced him from the dry study of law, and he entirely withdrew from taking any share in the active business of life. He died at an early age, leaving behind him a collection of elegies divided into four books, of which the last is supposed to have been published by one of his friends after his death. Nobbe, a German critic, who has examined the subject with considerable care, thinks that the first book was published not before 29 B. C., and not after 27 B. C.; the second book not before 24 B. C.; the third not before 21 B. C.; the fourth not before 16 B. C.

Many of his elegies are addressed to his mistress Cynthia, to whom he remains constant, though he suffers much from her cruelty. The language is powerful, and the structure of the verse correct, though not without some peculiarities; as, for example, the close of the pentameter line with a word of several syllables. In comparing the elegies of Propertius with those of Tibullus, we perceive that there is less of tenderness and softness, less of that simplicity for which Tibullus is so eminently distinguished; but, on the other hand, there is more spirit, a greater reach of thought, and more power of expression. He possesses much of the spirit of the lyric poet, and had talents which fitted him for things of greater moment than those upon which he bestowed them. Propertius was a close imitator of the Greek writers; Callimachus and Philetas were the poets whom he more particularly followed, so that he was sometimes called the Roman Callimachus. Like Callimachus, he is fond of displaying his learning, and has frequent allusion to mythological subjects; but this at times is the cause of some obscurity, and detracts from that simplicity which is the soul of true elegaic poetry. The best separate edition is that of Lachmann, with notes, Leipzig, 1816, but they are generally published along with Catullus and Tibullus.

PROPERTY, in a general sense, is a particular virtue or quality which nature has bestowed upon some things exclusive of all others. Thus, colour is a property of light; extension, figure, divisibility, and impenetrability, are properties of body.

PROPERTY, in *Law*, is described to be the highest right which a person has or can have to any thing. Definition.

The original foundation of the right of property.

There is nothing which so generally strikes the imagination and engages the affections of mankind, as the right of property; or that sole and despotic dominion which one man claims and exercises over certain external things of the world, in total exclusion of the right of any other individual in the universe. And yet there are very few that will give themselves the trouble to consider the origin and foundation of this right. Pleased as we are with the possession, we seem afraid to look back to the means by which it was acquired, as if suspicious of some defect in our title; or at best we rest satisfied with the decision of the

Property. laws in our favour, without examining the reason or authority upon which those laws have been built. We think it enough that our title is derived from the grant of the former proprietor, by descent from our ancestors, or by the last will and testament of the dying owner, not caring to reflect, that, strictly and accurately speaking, there is no foundation in nature or in natural law why a set of words upon parchment should convey the dominion of land; why the son should have a right to exclude his fellow-creatures from a determinate spot of ground, because his father had done so before him; or why the occupier of a particular field or of a jewel, when lying upon his death-bed, and no longer able to maintain possession, should be entitled to tell the rest of the world which of them should enjoy it after him. These inquiries, it must be owned, would be useless, and even troublesome, in common life. It is well if the mass of mankind obey the laws when made, without scrutinizing too nicely into the reasons of making them. But when law is to be considered not only as a matter of practice, but also as a rational science, it cannot be improper or useless to examine more deeply the rudiments and grounds of these positive constitutions of society.

This right arises from a divine grant.

In the beginning of the world, we are informed by Holy Writ, that the all-bountiful Creator gave to man dominion over all the earth; "over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth." This is the only true and solid foundation of man's dominion over external things, whatever airy metaphysical notions may have been started by fanciful writers upon this subject. The earth, therefore, and all things therein, are the general property of all mankind, exclusive of other beings, from the immediate gift of the Creator. And, whilst the earth continued thinly inhabited, it is reasonable to suppose that all was in common amongst them, and that every one took from the public stock to his own use such things as his immediate necessities required.

The state of property in the early ages of the world.

These general notions of property were then sufficient to answer all the purposes of human life, and might perhaps still have answered them, had it been possible for mankind to have remained in a state of primeval simplicity; as may be collected from the manners of many American nations, when first discovered by the Europeans, and from the ancient method of living amongst the first Europeans themselves, if we may credit either the memorials of them preserved in the golden age of the poets, or the uniform accounts given by historians of those times wherein *erant omnia communia et indivisa omnibus, veluti unum cunctis patrimonium esset.* Not that this communion of goods seems ever to have been applicable, even in the earliest ages, to aught but the *substance* of the thing; nor could it be extended to the *use* of it. For, by the law of nature and reason, he who first began to use it acquired therein a kind of transient property, that lasted as long as he was using it, and no longer; or, to speak with greater precision, the *right* of possession continued for the same time only that the *act* of possession lasted. Thus the ground was in common, and no part of it was the permanent property of any man in particular; yet whoever was in the occupation of any determinate spot of it, for rest, for shade, or the like, acquired for the time a sort of ownership, from which it would have been unjust, and contrary to the law of nature, to drive him by force; but the instant that he quitted the use or occupation of it, another might seize it without injustice. Thus also a vine or other tree might be said to be in common, as all were equally entitled to its produce; and yet any private individual might gain the sole property of the fruit which he had gathered for his own repast: a doctrine well illustrated by Cicero, who compares the world to a great theatre, which is common to the public, and yet the place which any man has taken is for the time his own.

But when mankind increased in number, craft, and ambition, it became necessary to entertain conceptions of more permanent dominion, and to appropriate to individuals, not the immediate *use* only, but the very *substance* of the thing to be used; otherwise innumerable tumults must have arisen, and the good order of the world been continually broken and disturbed, whilst a variety of persons were striving who should get the first occupation of the same thing, or disputing which of them had actually gained it. As human life also grew more and more refined, abundance of conveniencies were devised to render it more easy, commodious, and agreeable; such as habitations for shelter and safety, and raiment for warmth and decency. But no man would be at the trouble to provide either, as long as he had only an usufructuary property in them, which was to cease the instant that he quitted possession; if, as soon as he walked out of his tent, or pulled off his garment, the next stranger who came by would have a right to inhabit the one and to wear the other. In the case of habitations in particular, it was natural to observe, that even the brute creation, to whom everything else was in common, maintained a permanent property in their dwellings, especially for the protection of their young; that the birds of the air had nests, and the beasts of the field had caverns, the invasion of which they esteemed a very flagrant injustice, and would sacrifice their lives to preserve them. Hence a property was soon established in every man's house and home-stall; which seem to have been originally mere temporary huts or moveable cabins, suited to the design of Providence for more speedily peopling the earth, and suited to the wandering life of their owners, before any extensive property in the soil or ground was established. And there can be no doubt, but that moveables of every kind became sooner appropriated than the permanent substantial soil; partly because they were more susceptible of a long occupancy, which might be continued for months together without any sensible interruption, and at length by usage ripen into an established right; but principally because few of them could be fit for use, till improved and meliorated by the bodily labour of the occupant, which, bestowed upon any subject that before lay in common to all men, is universally allowed to give the fairest and most reasonable title to an exclusive property therein.

Property. Rise of permanent property in various things.

Nature of patriarchal property.

The article of food was a more immediate call, and therefore a more early consideration. Such as were not contented with the spontaneous product of the earth sought for a more solid refreshment in the flesh of beasts, which they obtained by hunting. But the frequent disappointments incident to that method of provision induced them to gather together such animals as were of a more tame and sequacious nature, and to establish a permanent property in their flocks and herds, in order to sustain themselves in a less precarious manner, partly by the milk of their dams, and partly by the flesh of the young. The support of these their cattle made the article of water also a very important point. And therefore the book of Genesis, the most venerable monument of antiquity, considered merely with a view to history, will furnish us with frequent instances of violent contentions concerning wells; the exclusive property of which appears to have been established in the first digger or occupant, even in places where the ground and the herbage remained yet in common. Thus we find Abraham, who was but a sojourner, asserting his right to a well in the country of Abimelech, and even exacting an oath for his security, "because he had digged that well." And Isaac, about ninety years afterwards, reclaimed this his father's property, and, after much contention with the Philistines, was suffered to enjoy it in peace.

All this while the soil and pasture of the earth remained still in common as before, and open to every occupant; except perhaps in the neighbourhood of towns, where the necessity of a sole and exclusive property in lands, for the

Property. sake of agriculture, was earlier felt, and therefore more readily complied with. Otherwise, when the multitude of men and cattle had consumed every convenience upon one spot of ground, it was deemed a natural right to seize upon and occupy such other lands as would more easily supply their necessities. This practice is still retained amongst the wild and uncultivated nations that have never been formed into civil states, like the Tartars and others in the East; where the climate itself, and the boundless extent of their territory, conspire to retain them still in the same savage state of vagrant liberty, which was universal in the earliest ages, and which Tacitus informs us continued amongst the Germans till the decline of the Roman empire. We have also a striking example of the same kind in the history of Abraham and his nephew Lot. When their joint substance became so great, that pasture and other conveniencies grew scarce, the natural consequence was, that a strife arose between their servants; so that it was no longer practicable to dwell together. This contention Abraham endeavoured to compose: "Let there be no strife, I pray thee, between thee and me. Is not the whole land before thee? Separate thyself, I pray thee, from me: if thou wilt take the left hand, then I will go to the right; or if thou depart to the right hand, then I will go to the left." This plainly implies an acknowledged right, in either, to occupy whatever ground he pleased, that was not pre-occupied by other tribes. "And Lot lifted up his eyes, and beheld all the plain of Jordan, that it was well watered everywhere, even as the garden of the Lord. Then Lot chose him all the plain of Jordan, and journeyed east; and Abraham dwelt in the land of Canaan."

Upon the same principle was founded the right of migration, or sending colonies to find out new habitations, when the mother-country was overcharged with inhabitants; which was practised as well by the Phœnicians and Greeks, as by the Germans, Scythians, and other northern people. And, as long as it was confined to the stocking and cultivation of desert uninhabited countries, it kept strictly within the limits of the law of nature.

Necessity of property, and of laws respecting it.

But as the world by degrees grew more populous, it daily became more difficult to find out new spots to inhabit, without encroaching upon former occupants; and by constantly occupying the same individual spot, the fruits of the earth were consumed, and its spontaneous produce destroyed, without any provision for a future supply or succession. It therefore became necessary to pursue some regular method of providing a constant subsistence; and this necessity produced, or at least promoted and encouraged, the art of agriculture. And the art of agriculture, by a regular connection and consequence, introduced and established the idea of a more permanent property in the soil than had hitherto been received and adopted. It was evident that the earth would not produce her fruits in sufficient quantities without the assistance of tillage; but who would be at the pains of tilling it, if another might watch an opportunity to seize upon and enjoy the product of his industry, art, and labour? Had not therefore a separate property in lands, as well as moveables, been vested in some individuals, the world must have continued a forest, and men have been mere animals of prey; which, according to some philosophers, is the genuine state of nature. Whereas now, so graciously has Providence interwoven our duty and our happiness together, the result of this very necessity has been the ennobling of the human species, by giving it opportunities of improving its rational faculties, as well as of exerting its natural. Necessity begat property; and in order to insure that property, recourse was had to civil society, which brought along with it a long train of inseparable concomitants; states, governments, laws, punishments, and the public exercise of religious duties. Thus connected together, it was found that a part only of society was sufficient to provide, by their manual labour, for the necessary subsistence of all; and Property. leisure was given to others to cultivate the human mind, to invent useful arts, and to lay the foundation of science.

Property acquired first by occupancy.

The only question remaining is, How this property became actually vested, or what it is that gave a man an exclusive right to retain in a permanent manner that specific land which before belonged generally to every body, and particularly to nobody? And, as we before observed that *occupancy* gave the right to the temporary *use* of the soil, so it is agreed upon all hands, that occupancy gave also the original right to the permanent property in the *substance* of the earth itself, which excludes every one else but the owner from the use of it. There is indeed some difference amongst the writers on natural law, concerning the reason why occupancy should convey this right, and invest one with this absolute property: Grotius and Puffendorf insisting that this right of occupancy is founded upon a tacit and implied assent of all mankind, that the first occupant should become the owner; and Barbeyrac, Titius, Locke, and others, holding that there is no such implied assent, neither is it necessary that there should be, as the very act of occupancy alone, being a degree of bodily labour, is, from a principle of natural justice, without any consent or compact, sufficient of itself to found a title. The dispute, however, savours too much of nice and scholastic refinement. But both sides agree in this, that occupancy is the thing by which the title was in fact originally acquired; every man seizing to his own continued use such spots of ground as he found most agreeable to his own convenience, provided he found them unoccupied by any one else.

By what means it is preserved or lost.

Property, both in lands and moveables, being thus originally acquired by the first taker, which taking amounts to a declaration that he intends to appropriate the thing to his own use, it remains in him, by the principle of universal law, till such time as he does some other act which shows an intention to abandon it; for then it becomes, naturally speaking, *publici juris* once more, and is liable to be again appropriated by the next occupant. So if one is possessed of a jewel, and casts it into the sea or a public highway, this is such an express dereliction, that a property will be vested in the first fortunate finder who shall seize it to his own use. But if he hides it privately in the earth, or other secret place, and it is discovered, the finder acquires no property therein; for the owner had not by this act declared any intention to abandon it, but rather the contrary; and if he loses or drops it by accident, it cannot be collected from thence that he designed to quit the possession; wherefore in such cases the property still remains in the loser, who may claim it again of the finder. And this, we may remember, is the doctrine of the English law with relation to *treasure-trove*.

But this method of one man's abandoning his property, and another seizing the vacant possession, however well founded in theory, could not long subsist in fact. It was calculated merely for the rudiments of civil society, and necessarily ceased amongst the complicated interests and artificial refinements of polite and established governments. In these it was found, that what became inconvenient or useless to one man, was highly convenient and useful to another, who was ready to give in exchange for it some equivalent that was equally desirable to the former proprietor. This mutual convenience introduced commercial traffic, and the reciprocal transfer of property by sale, grant, or conveyance; which may be considered either as a continuance of the original possession which the first occupant had, or as an abandoning of the thing by the present owner, and an immediate successive occupancy of the same by the new proprietor. The voluntary dereliction of the owner, and delivering the possession to another individual, amount to a transfer of the property; the proprietor declaring his intention no longer to occupy the thing himself, but that his

Property.

own right of occupancy shall be vested in the new acquirer. Or, taken in the other light, if I agree to part with an acre of my land to Titius, the deed of conveyance is an evidence of my intending to abandon the property; and Titius, being the only or first man acquainted with such my intention, immediately steps in and seizes the vacant possession. Thus the consent expressed by the conveyance gives Titius a good right against me, and possession or occupancy confirms that right against all the world besides.

How it goes on the death of the occupant.

The most universal and effectual way of abandoning property is by the death of the occupant, when, both the actual possession and intention of keeping possession ceasing, the property, which is founded upon such possession and intention, ought also to cease of course. For, naturally speaking, the instant a man ceases to be, he ceases to have any dominion; otherwise, if he had a right to dispose of his acquisitions one moment beyond his life, he would also have a right to direct their disposal for a million of ages after him, which would be highly absurd and inconvenient. All property must therefore cease upon death, considering men as absolute individuals, and unconnected with civil society; for then, by the principles before established, the next immediate occupant would acquire a right in all that the deceased possessed. But as, under civilized governments, which are calculated for the peace of mankind, such a constitution would be productive of endless disturbances, the universal law of almost every nation, which is a kind of secondary law of nature, has either given the dying person a power of continuing his property, by disposing of his possessions by will; or, in case he neglects to dispose of it, or is not permitted to make any disposition at all, the municipal law of the country then steps in, and declares who shall be the successor, representative, or heir of the deceased; that is, who alone shall have a right to enter upon this vacant possession, in order to avoid that confusion which its becoming common again would occasion. And farther, in case no testament be permitted by the law, or none be made, and no heir can be found so qualified as the law requires, still, to prevent the robust title of *occupancy* from again taking place, the doctrine of escheats is adopted in almost every country, whereby the sovereign of the state, and those who claim under his authority, are the ultimate heirs, and succeed to those inheritances to which no other title can be formed.

Of the right of inheritance.

The right of inheritance, or descent to the children and relations of the deceased, seems to have been allowed much earlier than the right of devising by testament. We are apt to conceive at the first view that it has nature on its side; yet we often mistake for nature what we find established by long and inveterate custom. It is certainly a wise and effectual, but clearly a political, establishment; since the permanent right of property, vested in the ancestor himself, was not a natural, but merely a civil, right. It is true, that the transmission of one's possessions to posterity has an evident tendency to make a man a good citizen and a useful member of society: it sets the passions on the side of duty, and prompts a man to deserve well of the public, when he is sure that the reward of his services will not die with himself, but be transmitted to those with whom he is connected by the dearest and most tender affections. Yet, reasonable as this foundation of the right of inheritance may seem, it is probable that its immediate origin arose not from speculations altogether so delicate and refined, but, if not from fortuitous circumstances, at least from a plainer and more simple principle. A man's children or nearest relations are usually about him on his death-bed, and are the earliest witnesses of his decease. They became therefore generally the next immediate occupants, till at length in process of time this frequent usage ripened into general law. And therefore also in the earliest ages, on the failure of children, a man's servants born under his roof were allowed to be his heirs, being immediately on the spot when he died. For we find the patriarch Abraham expressly declaring, that "since God had given him no seed, his steward Eliezer, one born in his house, was his heir."

Property.

Whilst property continued only for life, testaments were useless and unknown; and when it became inheritable, the inheritance was long indefeasible, and the children or heirs at law were incapable of exclusion by will; until at length it was found, that so strict a rule of inheritance made heirs disobedient and headstrong, defrauded creditors of their just debts, and prevented many provident fathers from dividing or charging their estates as the exigencies of their families required. This introduced pretty generally the right of disposing of one's property, or a part of it, by *testament;* that is, by written or oral instructions properly witnessed and authenticated, according to the pleasure of the deceased, which we therefore emphatically style his *will.* This was established in some countries much later than in others. In England, till modern times, a man could only dispose of one third of his moveables from his wife and children; and in general, no will was permitted of lands till the reign of Henry VIII. and then only of a certain portion; for it was not till after the Restoration that the power of devising real property became so universal as at present.

Last wills or testaments.

These are creatures of the civil laws.

Wills, therefore, and testaments, rights of inheritance, and successions, are all of them creatures of the civil or municipal laws, and accordingly are in all respects regulated by them; every distinct country having different ceremonies and requisites to make a testament completely valid. Neither does any thing vary more than the right of inheritance under different national establishments. In England particularly, this diversity is carried to such a length, as if it had been meant to point out the power of the laws in regulating the succession to property, and how futile every claim must be that has not its foundation in the positive rules of the state. In personal estates, the father may succeed to his children; in landed property, he never can be their immediate heir by any the remotest possibility. In general, only the eldest son, in some places only the youngest, in others all the sons together, have a right to succeed to the inheritance. In real estates, males are preferred to females, and the eldest male will usually exclude the rest; in the division of personal estates, the females of equal degree are admitted together with the males, and no right of primogeniture is allowed.

Scruples respecting heritable property removed.

This one consideration may help to remove the scruples of many well-meaning persons, who set up a mistaken conscience in opposition to the rules of law. If a man disinherits his son, by a will duly executed, and leaves his estate to a stranger, there are many who consider this proceeding as contrary to natural justice; whilst others so scrupulously adhere to the supposed intention of the deed, that if a will of lands be attested by only two witnesses instead of three, which the law requires, they are apt to imagine that the heir is bound in conscience to relinquish his title to the devisee. But both of them certainly proceed upon very erroneous principles: as if, on the one hand, this son had by nature a right to succeed to his father's lands; or as if, on the other, the owner was by nature entitled to direct the succession of his property after his own decease; whereas the law of nature suggests, that on the death of the possessor, the estate should again become common, and be open to the next occupant, unless otherwise ordered, for the sake of civil peace, by the positive law of society. The positive law of society, which is with us the municipal laws of England and Scotland, directs it to vest in such person as the last proprietor shall by will, attended with certain requisites, appoint; and, in defect of such appointment, to go to some particular person, who, from the result of certain local constitutions, appears to be

Prophecy || Prophet.

the heir at law. Hence it follows that, where the appointment is regularly made, there cannot be a shadow of right in any one but the person appointed; and, where the necessary requisites are omitted, the right of the heir is equally strong, and built upon as solid a foundation as the right of the devisee would have been supposing such requisites were observed.

Of things that are still in common.

But, after all, there are some few things which, notwithstanding the general introduction and continuance of property, must still unavoidably remain in common, being those in which nothing but an usufructuary property is capable of being had; and therefore they still belong to the first occupant, during the time he holds possession of them, and no longer. Such, amongst others, are the elements of light, air, and water, which a man may occupy by means of his windows, his gardens, his mills, and other conveniencies; such also are the generality of those animals which are said to be *feræ naturæ*, or of a wild and untameable disposition, and which any man may seize upon and keep for his own use or pleasure. All these things, as long as they remain in possession, every man has a right to enjoy without disturbance; but if once they escape from his custody, or he voluntarily abandons the use of them, they return to the common stock, and any other man has an equal right to seize and enjoy them afterwards.

Of similar things which have been appropriated.

Again, there are other things in which a permanent property may subsist, not only as to the temporary use, but also the solid substance; and which yet would frequently be found without a proprietor, had not the wisdom of the law provided a remedy to obviate this inconvenience. Such are forests and other waste grounds, which were omitted to be appropriated in the general distribution of lands: such also are wrecks, estrays, and that species of wild animals which the arbitrary constitutions of positive law have distinguished from the rest by the well-known appellation of *game*. With regard to these and some others, as disturbances and quarrels would frequently arise amongst individuals contending about the acquisition of this species of property by first occupancy, the law has therefore wisely cut up the root of dissension, by vesting the things themselves in the sovereign of the state, or else in his representatives appointed and authorized by him, being usually the lords of manors. And thus our legislature has universally promoted the grand ends of civil society, the peace and security of individuals, by steadily pursuing that wise and orderly maxim, of assigning to everything capable of ownership a legal and determinate owner.

Literary PROPERTY. See COPY-RIGHT.

PROPHECY is a word derived from προφητια, and in its original import signifies the prediction of future events. As God alone can perceive with certainty the future actions of free agents, and the remote consequences of those laws of nature which he himself established, prophecy, when clearly fulfilled, affords the most convincing evidence of an intimate and supernatural communion between God and the person who uttered the prediction. Hence this, together with the power of working miracles, is indeed the only evidence which can be given of such a communion. See THEOLOGY.

PROPHET, in general, a person who foretells future events; but it is particularly applied to such inspired persons amongst the Jews as were commissioned by God to declare his will and purposes to that people. Amongst the canonical books of the Old Testament we have the writings of sixteen prophets, four of whom are denominated the *greater prophets*, viz. Isaiah, Jeremiah, Ezekiel, and Daniel, being so called from the length and extent of their writings, which exceed those of the others, viz. Hosea, Joel, Amos, Obadiah, Jonah, Micah, Nahum, Habakkuk, Haggai, Zechariah, and Malachi, who are called the *lesser prophets*, from the shortness of their writings. The Jews do not place Daniel amongst the prophets, because, they say, he lived the life of a courtier rather than that of a prophet.

Propitiation || Proposition.

PROPITIATION, in *Theology*, is a sacrifice offered up to God to assuage his wrath and render him propitious. Amongst the Jews there are both ordinary and public sacrifices, as holocausts, and the like, offered by way of thanksgiving; and extraordinary ones, offered by particular persons guilty of any crime, by way of propitiation. The church of Rome believes the mass to be a sacrifice of propitiation for the living and the dead. The reformed churches allow of no propitiation but that one offered up by Jesus Christ on the cross. See THEOLOGY.

PROPONTIS, or SEA OF MARMORA, a part of the Mediterranean, dividing Europe from Asia. It has the Hellespont, or Canal of the Dardanelles, to the south-west, whereby it communicates with the Archipelago, and the ancient Bosphorus of Thrace, or Strait of Constantinople, to the north-east, communicating with the Black or Euxine Sea. It has two castles; that on the Asiatic side is on a cape, where formerly stood a temple of Jupiter. The Castle of Europe is on the opposite cape, and had anciently a temple of Serapis.

PROPORTION, the identity or similitude of two ratios. Hence quantities that have the same ratio between them are said to be proportional. Thus, if A be to B as C to D, or 8 be to 4 as 30 to 15; A, B, C, D, and 8, 4, 30, and 15, are said to be in proportion, or are simply called proportionals. Proportion is frequently confounded with ratio; yet have the two in reality very different ideas, which ought by all means to be distinguished. Ratio is properly the relation or habitude of two things, which determines the quantity of one from the quantity of another, without the intervention of any third. Thus we say the ratio of 5 and 10 is 2, the ratio of 12 and 24 is 2. Proportion is the sameness or likeness of two such relations; thus the relations between 5 and 10 and 12 and 24 being the same, or equal, the four terms are said to be in proportion. Hence ratio exists between two numbers, but proportion requires at least three. Proportion, in fine, is the habitude or relation of two ratios when compared together; as ratio is of two quantities.

PROPORTION, *Harmonical* or *Musical*. This subject, as usually treated, has little or no practical nor even theoretical utility. Enough regarding the ratios of musical sounds and intervals will be found under the articles MUSIC and TEMPERAMENT.

Arithmetical and Geometrical PROPORTION. See PROGRESSION.

Inordinate PROPORTION is where the order of the terms compared is disturbed or irregular. As, for example, in two ranks of numbers, three in each rank, namely,

in one rank.....2, 3, 9,
and in the other.....8, 24, 36,

which are proportional, the former to the latter, but in a different order, viz.....2 : 3 : : 24 : 36,
and.....3 : 9 : : 8 : 24.

Then, casting out the mean terms in each rank, it is concluded that.....2 : 9 : : 8 : 36,

that is, the first is to the third in the first rank as the first is to the third in the second rank.

PROPORTIONAL, relating to proportion. Thus we say, proportional compasses, parts, scales, spirals, and the like.

PROPORTIONALS, in *Geometry*, are quantities, either linear or numeral, which bear the same ratio or relation to each other.

PROPOSITION, in *Logic*, part of an argument, in which some quality, either negative or positive, is attributed to a subject.

PROPOSITION, in *Mathematics*, is either some truth advanced and shown to be such by demonstration, or some

operation proposed and its solution explained. If the proposition be deduced from several theoretical definitions compared together, it is called a *theorem ;* if from a praxis, or series of operations, it is called a *problem.*

PROPREFECT, amongst the Romans, the prefect's lieutenant, or an officer whom the prefect of the prætorium commissioned to do part of his duty in his stead.

PROPRETOR, or PROPRÆTOR, a Roman magistrate, who, having discharged the office of prætor at home, was sent into a province to command there with his former prætorial authority. It was also an appellation given to those who, without having been prætors at Rome, were sent extraordinarily into the provinces to administer justice with the authority of prætors.

PRO RATA, in commerce, a term sometimes used by merchants for *in proportion ;* as, each person must reap the profit or sustain the loss *pro rata* to his interest, that is, in proportion to his stock.

PROROGATION, the act of prolonging, or adjourning, or putting off to another time. The difference between a prorogation and an adjournment of parliament is, that by prorogation the session is ended, and such bills as passed in either house, or both houses, and had not the royal assent, must at the next assembly begin again.

PROSE, the natural language of mankind, loose and unconfined by poetical measures or restraints ; and in this sense it stands opposed to verse. The word *prose* comes from the Latin *prosa,* which some have derived from the Hebrew *poras,* which signifies *expendit ;* whilst others deduce it from the Latin *prorsa,* of *prorsus,* going forwards, by way of opposition to *versa,* or turning backwards, as is necessary in writing.

PROSERPINE, in fabulous history, the daughter of Jupiter and Ceres, who was carried off by Pluto as she was gathering flowers with her companions. Ceres, disconsolate for the loss of her daughter, after having long sought her, heard where she was, and entreated Jupiter to permit her to return from hell. This request Jupiter granted, on condition that she had not tasted anything in Pluto's dominions. Ceres therefore went to fetch her ; but when her daughter was preparing to return, Ascalaphus gave information that he had seen Prosperine eat some grains of a pomegranate she had gathered in Pluto's garden ; on which she was sentenced to continue in Tartarus in quality of Pluto's spouse, and the queen of those gloomy regions : but, to mitigate the grief of Ceres for her disappointment, Jupiter granted that her daughter should only spend six months in hell together with her husband, and the other six on earth with her mother. Some mythologists imagine that the latter part of the fable alludes to the corn, which must remain all the winter hidden in the earth, in order to sprout forth in the spring, and produce the harvest.

PROSEUCHE, in *Antiquity,* properly signifies *prayer ;* but it is taken for the places of prayer of the Jews, and was pretty nearly the same as their synagogues. But the synagogues were originally in the cities, and were covered places ; whereas, for the most part, the proseuches were out of the cities, and on the banks of rivers, having no covering except perhaps the shade of some trees or covered galleries. The word is Greek, προσευχη, *prayer.*

PROSLAMBANOMENOS (Greek, προσλαμβανομενος, the term προσλαμβανομενη being found as an exception in Bryennius only) signifies a lower string (χορδη) or sound (φθογγος) added to what was previously the lowest sound of the ancient Greek system of conjunct and disjunct tetrachords. For example, to the sounds BCDE, EFG*a,* forming two conjunct tetrachords in the lowest part of the scale, was added A, an octave below the last of the sounds above named. This formed a series of sounds similar to that of our minor scale when its 6th and 7th are made minor ; thus, ABCDEFG*a,* ascending diatonically from A in the lowest space of the stave with bass-clef, to A upon the highest line of the stave with same clef. In this place we may mention, that the ancient Perfect System, or Immutable System of the Greeks, as it is described by Greek writers on music, appears to have consisted of fifteen sounds comprehended within two octaves, reckoning from the Proslambanomenos above described, up to a sound two octaves higher. The order of these sounds, and their ancient Greek names and modern literal names, ascending, are as follows : Proslambanomenos A, Hypate-hypaton B, Parypate-hypaton C, Lichanos-hypaton D, Hypate-meson E, Parypate-meson F, Lichanos-meson G, Mese *a,* Paramese *b,* Trite-diezeugmenon *c,* Paranete-diezeugmenon *d,* Nete-diezeugmenon *e,* Trite-hyperbolæon *f,* Paranete-hyperbolæon *g,* Nete-hyperbolæon *ā.* Some of these strings or sounds were called Apycni, Baropycni, Mesopycni, Oxypycni. Some, too, were *fixed,* and others *moveable.* For various observations upon Greek scales, and upon certain oriental scales and ecclesiastical scales, see the article MUSIC, and Appendix to Graham's *Essay on the Theory and Practice of Musical Composition,* 1838.

The texts of the ancient Greek writers upon music are so corrupted, and so obscure in many respects, and contain so little of a really *practical* or useful nature, that we have purposely refrained from inserting in this work many old Greek theoretical terms, of which the exact signification is now lost. Attempts to explain these could end in nothing better than vague and useless conjectures. Those who feel any particular interest in the very obscure subject of ancient Greek music, may consult the Greek writers edited by Meibomius and Wallis, and various other ancient writers who treat of music expressly or incidentally ; also Hawkins, Burney, Forkel, and others.

PROSODY, that part of grammar which treats of the quantities and accents of syllables, and the manner of making verses.

PROSOPOPŒIA, a figure in oratory, by which we raise qualities of things inanimate into persons.

PROSTYLE, in *Architecture,* means a range of columns in the front of a temple.

PROSZNITZ, a city of the Austrian province of Moravia, in the circle of Olmutz. It is the capital of the principality of Lichtenstein, being situated on the river Rumza, in a fertile district, and contains 540 houses, with 8500 inhabitants, who are occupied in extensive distilleries, and in making woollen goods of a fine quality, besides some linens.

PROTAGORAS, a celebrated sophist of Abdera, was the son of Artemon or Mæandrios, and flourished 444 B. C. His poverty had compelled him to adopt the humble trade of a wood-carrier, when some circumstance attracted the notice of his countryman Democritus, and he was admitted as one of his pupils. After he had profited sufficiently by the instruction of Democritus, he proceeded to Athens, where he opened a school, which was attended by all the most illustrious men of the age. Amongst others, Pericles is said to have been his pupil. Protagoras is said to have been the first who set a price on his instruction, and by this means he was enabled to amass a large fortune. Plato, who was his avowed opponent, is willing to allow that Protagoras possessed a lively and fertile imagination, a wonderful memory, and great eloquence ; but he was vain, impudent, and presumptuous ; he spoke of his rivals with contempt, and of himself with a degree of confidence which excited the admiration of the vulgar. In the *Theætetus* of Plato we have a summary of the doctrines of this philosopher. Protagoras having in one of his works declared that he could not argue on the nature of the gods, because he was not certain of their existence, he was accused of impiety, and condemned to suffer death, or, according to others, banishment. On his passage to Sicily he suffered

Protasis ‖ Protractor.

shipwreck, and was drowned. His works were collected by order of the magistrates, and condemned to the flames. See Hardion, *Dissertation sur l'Origine et les Progrès de la Rhétorique*, in the fifteenth volume of the *Mémoires de l'Académie des Inscriptions*, p. 148.

PROTASIS, in the ancient drama, the first part of a comic or tragic piece, in which the several persons are announced, their characters intimated, and the subject of the piece proposed and entered upon.

PROTESTANT, a name first given in Germany to those who adhered to the doctrine of Luther, because, in 1529, they protested against a decree of the Emperor Charles V. and the Diet of Spires, declaring that they appealed to a general council. The same name has now become a common denomination for all those of the reformed churches.

PROTHONOTARY, a term which properly signifies *first notary*, and which was anciently the title of the principal notaries of the emperors of Constantinople.

Prothonotary is with us an officer in the court of king's bench and in that of common pleas, the former of which has one, and the latter three. The prothonotary of the king's bench records all civil actions sued in that court, as the clerk of the crown-office does all criminal causes. The prothonotaries of the common pleas enter and enrol all declarations, pleadings, assizes, judgments, and actions; make out all judicial writs, except writs of *habeas corpus* and *distringas jurator*, enter recognizances acknowledged, and all common recoveries; and make exemplifications of records, &c.

In the court of Rome there is a college of twelve prelates, called *apostolical prothonotaries*, empowered to receive the last wills of cardinals, to direct all informations and proceedings necessary for the canonization of saints, and to attend on the pope whenever he performs any extraordinary ceremony out of Rome.

PROTO, a Greek term, frequently used in composition, and signifying priority.

PROTOGENES, a celebrated painter, was a native of Xanthus, in Caria, and flourished 330 B. C., in the time of Alexander the Great, being the contemporary of Apelles. Protogenes lived principally in Rhodes, where he was held in little honour by his neighbours, until Apelles paid him a visit, and declared that Protogenes was only inferior to himself in one particular, that he bestowed too much pains in finishing his paintings. From that moment the reputation of Protogenes was established. His finest painting was that representing the grandson of Sol, which he took seven years to finish, having put on it four courses of colour, that it might be less liable to be obliterated by age. Having been placed in a temple at Rhodes, when the city was besieged by Demetrius, and the painting in danger of being destroyed, Demetrius is said to have retired rather than it should run any risk. It was afterwards carried to Rome and placed in the Temple of Peace, where it was destroyed by fire. There was a dog in this picture, which the painter wished to represent with foam at its mouth; but, after many vain attempts, he threw his brush in a fury at the spot, and by a strange accident produced the very effect he wanted. He also painted a satyr playing on the shepherd's pipe, which is said to have been very fine; likewise a portrait of Pythias the mother of the philosopher Aristotle, a Pan, and portraits of Alexander. He was the author of two books on painting.

PROTOTYPE is the original or model after which a thing has been formed; but it is chiefly used for the patterns of things to be engraved, cast, or sculptured.

PROTRACTOR, an instrument for laying down and measuring, with accuracy and despatch, angles upon paper, and by which the use of the line of chords is superseded. This instrument is variously formed, and constructed of different materials; and it is necessary in laying down those surveys or other plans where angles are concerned.

Proveditor ‖ Providence.

PROVEDITOR, an officer in several parts of Italy, particularly at Venice, who has the direction of matters relating to policy.

PROVENCE, a province or government of France, bounded by Dauphiné on the north, by Piedmont on the east, by the Mediterranean on the south, and by the river Rhone, which separates it from Languedoc, on the west. It is about 100 miles in length, and nearly as many in breadth.

PROVENDER originally signified a kind of vessel containing the measure of corn daily given to a horse, or other beast of labour, for his subsistence; but it is now generally used to signify the food for cattle, whatever it may consist of.

PROVERB, according to Camden, is a concise, witty, and wise speech, grounded upon experience, and for the most part containing some useful instruction.

Book of PROVERBS, a canonical book of the Old Testament, containing a part of the proverbs of Solomon the son of David king of Israel. The first twenty-four chapters are acknowledged to be the genuine work of that prince; the next five chapters are a collection of several of his proverbs made by order of King Hezekiah; and the two last seem to have been added by different but unknown authors.

PROVIDENCE, the superintendent care which God exercises over creation, material and spiritual.

Belief of a providence universal.

That there exists a divine providence which attends to the affairs of this world, and directs their course, has been a received opinion amongst the human race in every country and in every period of history. Every altar that is erected, every prayer and every sacrifice that is offered up, affords a proof of this belief. So fully have men been convinced of the sincerity of each other's faith upon this subject, that in one form, that of an appeal to the Divine Ruler of the world, by the solemnity of an oath, they have introduced it into the most ordinary as well as the most important business of life.

But this doctrine has been disputed.

But notwithstanding this universal reception, in some form or other, of the doctrine of a divine providence, it has in every age met with some opponents. The most ancient of these were Democritus and Leucippus. They denied the existence of a Deity, asserted that all things were mechanically necessary, and maintained that thought and sense were only modifications of matter. This is atheism in the strictest sense, and the only form of it that has ever been consistently supported. Epicurus followed upon the same principles; but he rendered the system altogether absurd, by confessing the freedom of the human will. To avoid the imputation of atheism, he asserted the existence of God; but declared that the Deity resided above the heavens, and interfered not in human affairs. One of his maxims was, that "the blessed and immortal Being neither has any employment himself, nor troubles himself with others." Maximus Tyrius justly observes, that this is rather a description of Sardanapalus than of a Deity, whose very existence implies his government. And some of the moralists of antiquity remarked, that they knew many men amongst themselves, possessed of active and generous minds, whose characters they valued more highly than that of Epicurus's god. Some of the ancients also appear to have entertained a strange notion. They acknowledged the existence of a Supreme and of many inferior deities; but they at the same time supposed that there is a certain fate which rules over all, and is superior to the gods themselves.

The providence exerted by the Author of nature over his works is usually divided into two branches; a *general*, referring to the management of the universe at large; and a *particular* providence, chiefly regarding particular men.

General providence.

Upon the first of these, in Wollaston's *Religion of Nature delineated*, the question is stated somewhat in the following manner. The world may be said to be governed, or at least cannot be said to fluctuate fortuitously, if there

Providence. be laws or rules by which natural causes act; if the several phenomena in it succeed regularly, and in general the constitution of things is preserved; if there are rules observed in the production of herbs, trees, and the like; if the several kinds of animals are furnished with faculties proper to determine their actions in the different stations which they hold in the general economy of the world; and, lastly, if rational beings are taken care of in such a manner as will at last agree best with reason. By the providence of God we ought to understand his governing the world by such laws as these now mentioned; so that if there are such, there must be a divine providence.

Inanimate objects. With regard to *inanimate objects*, the case agrees precisely with the above supposition. The whole of that universe which we see around us is one magnificent and well-regulated machine. The world that we inhabit is a large globe, which, conducted by an invisible power, flies, with a rapidity of which we have no conception, through an extent of space which sets at defiance every power of fancy to embody it into any distinct image. A large flaming orb stands immoveable in the heavens, around which this, and other worlds of different magnitudes, perform their perpetual revolutions. Hence arise the expected returns of day and night, and the regular diversity of seasons. Upon these great operations a thousand other circumstances depend. Hence, for example, the vapours ascend from the ocean, meet above in clouds, and, after being condensed, descend in showers to cover the earth with fertility and beauty. These appearances are regular and permanent. During every age since men have been placed upon the earth, this astonishing machine has continued steadily to perform its complicated operations. Nothing is left to chance. The smallest bodies are not less regular than the largest, and observe continually the same laws of attraction, repulsion, &c. The apparent variations of nature proceed only from different circumstances and combinations of things, acting all the while under their established laws. We ourselves can calculate the effects of the laws of gravitation and of motion. We can render them subservient to our own purposes, with entire certainty of success, if we only adhere to the rules established by nature, that is to say, by providence.

Vegetables. *Vegetables* also live and flourish according to prescribed methods. Each sort is produced from its proper seed, has the same texture of fibres, is at all times nourished by the same kind of juices, digested and prepared by the same vessels. Trees and shrubs receive annually their peculiar liveries, and bear their proper fruits. So regular are they in this last respect, that every species may be said to have its profession or trade appointed to it, by which it furnishes a certain portion of manufacture, or of food, to supply the wants of animals. Being created for the purpose of consumption, all vegetables produce great quantities of seed to supply the necessary waste. Here, then, there is evidently a *regulation* by which the several orders are preserved, and the ends of them answered according to their first establishment.

Animals. With regard to *animals*, they too, in structure of their form, are subject to laws similar to those which govern the vegetable world. In the sentient part of their constitution they are no less subject to rule. The lion is always fierce, the fox crafty, and the hare timid. Every species retains from age to age its appointed place and character in the great family of nature. The various tribes are created and placed in such a manner as to find proper means of support and defence. Beasts, birds, fishes, and insects, are all possessed of organs and faculties adapted to their respective circumstances and opportunities of finding their proper food and prey.

Man. *Man* is subject to the ordinary laws which other material and animal substances obey; but he is left more at large in the determination of his actions. Yet even here things do not fluctuate at random. Individuals do indeed rise and perish according to fixed rules; and nations themselves have only a temporary endurance. But the species advances with a steady progress to intellectual improvement. This progress is often interrupted; but it appears to be not less sure at the long-run than even the mechanical laws which govern the material part of our constitution. Amidst the convulsion of states and the ruin of empires, the useful arts, when once invented, are never lost. These, in better times, render subsistence easy, and give leisure for reflection and study to a greater number of individuals. Tyre and Sidon have passed away, Athens itself has become the prey of barbarians, and the prosperity of ancient Egypt is departed perhaps for ever; but the ship, and the plough, and the loom, remain, and have been perpetually improving. Thus every new convulsion of society does less mischief than the last; and it is hoped that, by the assistance of printing, the most polished arts and the most refined speculations have at length become immortal. The world is not then left in a state of confusion; it is reduced into order, and methodized for ages to come, the several species of beings having their offices and provinces assigned them. Plants, animals, men, and nations, are in a state of continual change; but successors are appointed to relieve them, and to carry on the *scheme of providence*. Providence.

Particular providence. But the great difficulty is how to account for that providence which is called *particular;* for rational beings and free agents are capable of doing and deserving well or ill; and the safety or danger, the happiness or unhappiness of a man here, must depend upon many things which seem scarcely capable of being determined by providence. Besides himself and his own conduct, he depends upon the conduct of other men, whose actions, as we naturally suppose, cannot, consistently with their free will, be controlled for the advantage of another individual. The actions of numbers of men, proceeding upon their private freedom, with different degrees of ability, as they cross and impede, or directly oppose each other, must produce very different effects upon men of different characters, and thus in a strange manner embarrass and entangle the general plan. And as to the course of nature, it may justly be asked, is the force of gravitation to be suspended till a good man pass by an infirm building? Add to this, that some circumstances appear absolutely irreconcileable. The wind which carries one into port drives another back to sea; and the rains which are just sufficient upon the hills may drown the inhabitants of the valleys. In short, may we expect miracles? or can there be a particular providence that foresees and prepares for the several cases of individuals, without force frequently committed upon the laws of nature and the freedom of intelligent agents?

No good argument against its existence. But in whatever way it is brought about, there is little doubt that something of this kind must take place. For as the Deity does direct, as already mentioned, the great and general progress of things in this world, he must also manage those of less importance. Nations are composed of individuals. The progress of individuals is the progress of the nation, and the greatest events usually depend upon the history and the most trifling actions of private persons. The difficulty is to conceive how the superintendence and management of all this can be brought about. But as the ways and the thoughts of the Omnipotent Spirit, whose influence pervades, and rules, and animates nature, resemble not the limited operations of men, we can only form conjectures concerning the means by which his government is conducted.

Objections. We shall next proceed to state some of the chief objections which, in ancient or modern times, have been brought against the opinion that the world is governed by a divine providence. And the first of these is, that the system of na- Imperfections of nature.

Providence.

ture contains many imperfections which it ought not to do if it be the work of a perfectly wise and good Being. To avoid the force of this objection, some modern writers have deserted the ground of supreme and absolute goodness, which the ancient theists always occupied, and have asserted that the divine perfection consists in unlimited power and uncontrolled supremacy of will; that, consequently, the Deity does not always that which is best, but merely what he himself pleases; and that for no other reason but because he wills so to do. But this is no better than atheism itself. For it is of no importance to us whether the universe is governed by blind fate or chance, that is to say, by nothing at all; or whether it is governed by an arbitrary sovereign will that is directed by chance, or at least by no principle of beneficence.

Answer.

The true answer to this objection is, that no created system can have every perfection, because it must necessarily be destitute of self-existence and independence; and therefore, if being destitute of some perfections be better than nothing, it was worthy of infinite power and perfect goodness to create such beings. In our present state, we mortals stand upon too low ground to take a commanding view of the whole frame of things. We can only reason concerning what is unknown from the little that is within our reach. But in this little we can see that wisdom and goodness reign, that nature always aims to produce perfection, that many salutary effects result even from the thunder and the storm; and we doubt not that a view of the whole structure of the universe would afford an additional triumph to the goodness and skill of its great Architect.

We see a regular ascent in the scale of beings from mere lifeless matter up to man; and the probability is, that the scale continues to ascend as far above man in perfection as created beings can possibly be raised. The sole purpose of God in creating the world must have been to produce happiness. But this would be most effectually done by creating, in the first place, as many of the most perfect class of beings as the system could contain; and afterwards other classes less and less perfect, till the whole universe should be completely full. We do not positively assert that such a scheme of creation was actually in the divine Architect's intention; but that it is possible, is sufficiently obvious. No man will pretend to say, that this earth could afford a comfortable subsistence to a greater number of the human race, were all the inferior animals annihilated, than it could at present, swarming as every element is with life. Suppose, then, that as many men had been placed at first upon the earth as it could possibly support, and that matters had been so constituted that the number should never have been either increased or diminished; we beg leave to ask, whether, since there would have been evidently room for inferior animals, it would have been most worthy of infinite goodness to leave the whole globe to men, or to introduce into it different orders of less perfect beings, which, whilst they could not incommode the principal inhabitant, would each find pleasure in its own existence? To this question different answers cannot surely be given. Let the reader then extend his view, and consider the universe, which, however vast, cannot be positively infinite, as one system so much united as the several parts of this globe are; let him suppose that there were at first created as many of the highest order of beings as it could have contained had creation stopt there; let him also remember that happiness in many different degrees is valuable; and he will not surely think it any imputation on the goodness of God that there are in the universe many beings far from perfection. The most imperfect of these are by themselves better than nothing; and they all contribute to make up a system which, considered as a whole, we have every reason to believe to be as perfect as anything not self-existent can possibly be.

If the world be conducted by a benevolent providence, how came evil to be introduced into it? This question has perplexed mankind in all ages. The ancient Persians resolved it by asserting the existence of two gods, Oromasdes the author of good, and Arimanius the author of evil. From them the Christian heretics called Manicheans borrowed their doctrine of two opposite co-eternal principles. Both the Platonists and Stoics ascribed the origin of evil to the perverseness or imperfection of matter, which they thought the Deity could not alter; and Pythagoras imagined a state of pre-existence, in which the souls of men had committed offences, for which they are here suffering the punishment. But these hypotheses are, some of them impious, and all unsatisfactory.

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Objection from the introduction of evil.

Taking the expression in its most extensive sense, the evils to which the human race are exposed may be reduced to pain, uneasiness, disappointment of appetites, and death; of which not one could have been wholly prevented without occasioning greater evils, inconsistent with the perfect goodness of the Creator. As long as we have solid bodies capable of motion, supported by food, subject to the influence of the atmosphere, and divisible, they must necessarily be liable to dissolution or death. But if a man could suffer death, or have his limbs broken, without feeling pain, the human race would have been long ago extinct. A fever is a state of the body in which the fluids are in great disorder. If we felt no uneasiness from that disorder, we should have no inducement to pay the proper attention to our state, and should certainly die unawares, without suspecting ourselves to be in danger; whereas, under the present administration of divine providence, the pain and sickness of the disease compel us to have recourse to the remedies proper for restoring us to soundness and health. Of the uneasinesses to which we are liable, and which are not the effect of immediate pain, the greatest has been sometimes said to arise from the apprehension of death, which constantly stares us in the face, and frequently embitters all our pleasures even in the hour of perfect health. But this dread of death is implanted in our breasts for the very best of purposes. Had we no horror at the apprehension of death, we should be apt, whenever any misfortune befell us, to quit this world rashly, and rush unprepared into the presence of our Judge; but the horror which attends our reflections upon our own dissolution, arising not from any apprehensions of the pain of dying, but from our anxiety concerning our future state of existence, tends strongly to make us act, whilst we are still here, in such a manner as to insure our happiness hereafter. Add to this, that the fear of death is the greatest support of human laws. We every day see persons breaking through all the regulations of society and good life, notwithstanding they know death to be the certain consequence, and feel all the horrors of it which are natural to man. Were death therefore divested of these horrors, how insignificant would capital punishments be as guardians of the law, and how insecure would individuals be in civil society?

Answer.

With regard to the unavoidable misfortunes and anxieties of our present state, these, so far from being truly hurtful in themselves, are proofs of divine beneficence. When we see men displeased with their situation, when we hear them complain of the difficulties, the miseries, and the cares of life, of the hardships which they have undergone, and the labours which still lie before them, instead of accounting them unfortunate, we ought to regard them as active beings, placed in the only situation which is fit for the improvement of their nature. That discontent, and these restless wishes to improve their condition, are so many sure indications that their faculties will not languish. They who are in the least degree accustomed to observe the human character, know well the influence which pleasure and repose have in enfeebling every manly principle, and how capable they are of attaching us even to a sordid and dishonourable existence.

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Happy indeed it is for the human race, that the number of those men is small whom providence has placed in situations in which personal activity is unnecessary. By far the greater number are compelled to exert themselves, and to mix and to contend with their equals, in the race of fortune and of honour. It is thus that our powers are called forth, and that our nature reaches its highest perfection. It is even perhaps a general truth, that they who have struggled with the greatest variety of hardships, as they always acquire the highest energy of character, so, if they have retained their integrity, and have not sunk entirely in the contest, seldom fail to spend their remaining days respectable and happy, superior to passion, and secured from folly by the possession of a wisdom dearly earned.

Objection from the permission of moral guilt.

The most serious difficulty lies in accounting for the permission of moral evil or guilt, in a system governed by infinite benevolence and wisdom. Those who in a consistent manner hold the doctrine of the absolute necessity of human actions in its full extent, and acknowledge all its consequences, find it easy to elude this difficulty. They very fairly deny the existence of any such thing as moral evil in the abstract; and assert, that what we call a *crime*, is nothing more than an action which we always regard with a painful sensation; that these apparent evils endure only for a time; and that all will at last terminate in the perfection and happiness of every intelligent being.

Answer.

Upon the system of liberty, the shortest answer seems to be this: That some things are absolutely impossible, not from any weakness in the Deity, but because they infer absurdity or contradiction. Thus it is impossible for twice two to be any thing else than four; and thus it is impossible for Omnipotence itself to confer self-approbation upon an intelligent being who has never deserved it; that is to say, it is impossible for a man of sense to be pleased with himself for having done a certain action, whilst he himself is conscious that he never did that action. But self-approbation constitutes the highest, the most unmingled, and the only permanent felicity, of which our nature is capable. It is not in the power of Omnipotence itself, then, to bestow the highest and most permanent felicity of our nature; it must be earned and deserved before it can be obtained. In the same manner good desert, virtue, or merit, cannot be conferred; they must be acquired. To enable us to acquire these, we must be exposed to difficulties, and must suffer in a certain degree. If these difficulties had no influence upon our conduct and feelings, if they exposed us to no real danger, no fabric of merit and of self-approbation could be reared upon them. All that the Supreme Being could do for us would have been to confer such an original constitution and character as should enable us to do well if we were to exert our utmost powers. The universe is not ruled by favour, but by justice. Complete felicity must be purchased. Guilt is an abuse of our freedom, a doing ill where we could have done well, and is entirely the work of man. Heaven could not avoid permitting its existence, and exposing us to danger; for temptation is necessary to virtue, and virtue is the perfection of our nature, our glory, and our happiness.

Objection from the apparent confusion of human affairs.

The last objection to the belief of a divine providence arises from the apparent confusion of human affairs, that all things happen alike to all, that bad men are prosperous, and that a total want of justice appears to attend the divine administrations. Even the best men have at times been shaken by this consideration. But there are many reasons for rendering this world a mixed scene; it would become unfit for a state of trial and of education to virtue if it were otherwise.

Answer.

It has been already shown, that physical evil is the parent of moral good; and therefore it would be absurd to expect that the virtuous should be entirely exempted from that evil. For the occasional prosperity of the wicked many reasons have been assigned, even by those who, in their disquisitions, were not guided by that revelation which has brought to light life and immortality. "God," says Plutarch, "spares the wicked, that he may set to mankind an example of forbearance, and teach them not to revenge their injuries too hastily on each other. He spares some wicked men from early punishment, in order to make them instruments of his justice in punishing others. And he spares all for a time, that they may have leisure for repentance; for men look at nothing further, in the punishments which they inflict, than to satisfy their revenge and malice, and therefore they pursue those who have offended them with the utmost rage and eagerness; whereas God, aiming at the cure of those who are not utterly incurable, gives them *time to be converted*."

Providence.

PROVIDENCE, the capital of Rhode Island, one of the United States of North America. It is situated at the head of the tide-waters of Naraganset Bay, immediately above the mouth of the Seekhouk, about thirty miles from the Atlantic Ocean. The town is built on both sides of an arm of the bay, which is usually called Providence River; and its position is pleasant, although on the sharp acclivities of hills. The two sections of Providence are connected by two bridges, one of which is ninety feet in length. This is a wealthy and flourishing town, and of late years has rapidly increased in importance. The buildings are chiefly of wood, uniformly painted white; but a number of them are composed of more substantial materials, as granite and brick. Those of a public nature are the State-house, the Arcade, the halls of Brown University, the Dexter Asylum, nearly twenty places of public worship, a number of public schools, and several large manufacturing establishments. The Arcade is the most splendid building of the kind in the Union. It presents two fronts of hammered granite, each seventy-two feet in width, and forming a colonnade of six columns of pure Grecian Doric. The body of the building is two hundred and twenty-two feet in length. Several of the churches are handsome structures. Brown University has two halls, both built of brick, and each containing about fifty rooms for students and the necessary business of the establishment. It was founded in the year 1764, and in 1838 contained ten instructors, 1253 alumni, 450 ministers, 187 students, 6000 volumes in the college library, and 5600 volumes in the students' libraries. There are also a number of public schools, a mechanics' and a manufacturers' association, an athenæum, a large asylum for the poor, a Friends' boarding school, which is a large and excellent establishment, and libraries attached to all or most of these, besides the Providence Library. About twelve newspapers are published in this city.

Providence was early a place of much commercial enterprise; but it is now most distinguished for its manufactures. There are four or five cotton factories; several extensive bleacheries, in which large quantities of cotton cloth from many of the factories in Rhode Island and other states are bleached and otherwise prepared; a number of dye-houses, founderies, and machine-shops, the two latter being employed principally in building cotton machinery. There are, besides, establishments for the manufacture of steam-engines, files, leather, shoes, soap, combs, hats, jewellery, and for working in tin and other metals; and there is also a large glass-house for the manufacture and cutting of flint-glass. In the year 1831, there were imported 55,707 bales of cotton, 71,369 barrels of flour, 216,662 bushels of corn, and 7772 bushels of rye. The imports in 1831 amounted to 457,717 dollars; and the exports, domestic and foreign, to 329,634 dollars. The amount of shipping registered for the same year was 12,362 tons; that enrolled, 4788 tons. It possesses a fine harbour, there being water for vessels of nine hundred tons burden close to the wharfs. Business is greatly promoted by a number of banks, which possess an aggregate capital of about five millions of dollars. This

Providence, New || Providence, Old.

town was founded in the year 1636 by one Williams, who was banished from Massachusetts on account of his religious tenets. It has repeatedly been nearly destroyed by fire and storm. In 1831 Providence was incorporated as a city, and divided into six wards, the municipal government being vested in a mayor, a board of aldermen, and a common council. The population, which in 1832 was about 20,000, cannot in 1839 be estimated under 30,000. Providence is situated forty miles south-south-west of Boston, thirty north of Newport, and one hundred and ninety north-east of New York, in lat. 41. 51. north, and long. 71. 26. west from Greenwich.

PROVIDENCE, a small island in the Pacific Ocean, seen by the Felice in the year 1783, in long. 127. 12. E. lat. 4. 2. N. Another in the Indian Ocean, in long. 52. 36. E. lat. 9. 10. S. And a third in long. 78. E. lat. 54. 5. N.

PROVIDENCE, NEW, one of the Bahama Islands, in the West Indies, situated between longitude 77. 10. and 77. 38. west, and latitude 25. 3. north. It is twenty-one miles in length from east to west, seven miles in breadth from north to south, and for the most part flat, and covered with brushwood and extensive lagoons. A low range of rocky hills traverses part of the island at a short distance from the sea, in a direction from east to west; and another ridge, called the Blue Hills, situated about two miles and a half inland, runs nearly parallel to the former. The soil is in many parts very productive, and there is abundance of water, which possesses the valuable property of keeping good at sea for any length of time. Vegetables and fruits thrive abundantly; beef, mutton, and poultry are good and plentiful, and the shores abound with fish, including turtle. Amongst the exports are cotton, bark, broziletto, and fustic. The climate is mild, equable, and salubrious. New Providence, from its harbour and relative situation with respect to the Florida channel, is considered as the most important of the Bahamas; and on it is situated Nassau, the seat of government for the islands, as well as the head-quarters of the naval and military establishments. It is the centre of commerce, and possesses a fine harbour nearly land-locked. The streets are regularly laid out, the buildings are good, and there is an air of liveliness and cleanliness about the place. The island is divided into parishes, each of which has its church, clergy, and school liberally provided for. New Providence was colonized by the English in the year 1629, the natives having by that time become totally extinct. In 1641 the Spaniards drove out the settlers; but they returned in 1666, to be again expelled, however, in 1703. In 1783 New Providence, along with the other Bahama Islands, was restored to Great Britain by treaty. The population is about 6000.

PROVIDENCE, OLD, an island of the Caribbean Sea, situated about 125 miles from the nearest point of the Mosquito coast, its centre being in latitude 13. 21. north, and longitude 81. 21. 50. west from Greenwich. Its shape is an irregular oval, four miles and a quarter in length by two and a half in breadth. It is surrounded by an extensive coral reef; and at its northern extremity is another smaller island called Santa Catalina, separated from Old Providence only by a very narrow channel. Both islands are very hilly, and present an agreeable variety of scenery. The soil is exceedingly productive, and vegetation flourishes luxuriantly. The cattle and horses are excellent; but cotton is the staple export, which, with turtle-shell and hides, are the principal articles of trade. These are annually taken away by traders in exchange for English goods brought from Jamaica. Isabella, the only village on the island, is situated at the northern extremity, close to the channel, between the two islands. It was once a populous and flourishing place, but has now fallen into decay. The island is under the government of New Grenada, and, with that of St Andrews, forms the ninth canton of the republic. Old Providence is noted in the history of piracy as having been the resort formerly of bucaneers, and latterly that of privateers. It is but thinly inhabited, and capable of supporting a much larger population.

Providential Channel || Pruning.

PROVIDENTIAL CHANNEL lies between some shoals in the South Pacific Ocean, through which the Endeavour passed, near the north-east coast of New Holland. Long. 137. 50. E. Lat. 5. 38. S.

PROVINCE, in *Geography*, a division of a kingdom or state, comprising several cities, towns, and districts, all under the same government, and usually distinguished by the extent either of the civil or the ecclesiastical jurisdiction.

The church distinguishes its provinces by archbishoprics; in which sense England is divided into two provinces, namely, Canterbury and York.

PROVINCIAL, something relating to a province. It also denotes, in Catholic countries, a person who has the direction of the conventual establishments of a province.

PROVINS, an arrondissement of the department of the Seine and Marne, in France. It extends over 486 square miles, is divided into five cantons and 106 communes, and contains 48,500 inhabitants. The capital is a city of the same name, situated on the river Bouzie. It is well built, and ornamented by good promenades; and it contains 880 houses, with 5760 inhabitants, who, besides carrying on the manufacture of mixed cloths, and a considerable trade in corn, cultivate a great quantity of roses for the perfumers of Paris. There is also a mineral spring of some celebrity. Long. 3. 12. E. Lat. 48. 33. 39. S.

PROVOST of a city or town, is a name applied to the chief municipal magistrate in corporate towns or cities. He presides in civic courts, and, with the bailies, who are his deputies, determines in all differences that arise amongst citizens.

PROVOST, or *Prévôt-Royal*, a sort of inferior judge formerly established throughout France, to take cognizance of all civil, personal, real, and mixed causes, amongst the people only.

Grand PROVOST of France, an officer who had jurisdiction in the king's house, and over the officers therein.

PROVOST-Marshal of an Army, is an officer appointed to seize and secure deserters, and all other criminals.

PROVOST of the Mint, a particular judge instituted for the apprehending and prosecuting of false coiners.

PROW, the head or fore-part of a ship, particularly in a galley, being that which is opposite to the poop or stern.

PROXIMITY denotes the relation of nearness, whether in respect of place, of blood, or of alliance.

PRUDENCE, in *Ethics*, may be defined an ability of judging what is best, in the choice both of ends and of means. According to the definition of the Roman moralist (*De Officiis*, lib. i. cap. 43), prudence is the knowledge of what is to be desired or avoided. Accordingly, he takes *prudentia* to be a contraction of *providentia*, or foresight. Plato calls this the leading virtue; and Juvenal observes, that where prudence is present no divinity is absent.

The extremes of prudence are craft or cunning on the one hand, and folly on the other.

PRUDENTIUS, or AURELIUS PRUDENTIUS CLEMENS, a famous Christian poet, who flourished under the reign of Theodosius the Great. Born in Spain in the year 348, he first followed the profession of advocate, was afterwards a judge, then a soldier, and at length had an honourable employment at court. A great number of his poems remain; but the style is barbarous, forming a singular contrast to the purity of the Augustan age. The best editions of his works are that of Amsterdam, 1667, with Heinsius's notes; and that of Paris, 1687, *in usum Delphini*.

PRUNING, in *Gardening* and *Agriculture*, is lopping off the superfluous branches of trees, to make them bear better fruit, grow higher, or appear more regular.

PRUSSIA.

History. PRUSSIA, formerly a duchy, but now a powerful and extensive kingdom of the second rank, was formed on the ancient electoral possessions as a nucleus, by means of successive territorial acquisitions, particularly in Poland, in Westphalia, and on the Rhine. The name is supposed by some to have been derived from that of the *Borussi*, a Sarmatian or Slavonic tribe, who, having migrated from the foot of the Riphæan Mountains, were tempted to settle in the district which is called Prussia proper. But others are of opinion that the country derived its name from its vicinity to the vast territory of Russia, and was for this reason called *Porussia; po* in the Slavonic language signifying *near* or *adjacent*, and consequently Porussia, shortened into Prussia, meaning near or adjacent to Russia. Nor is this derivation of the name entirely fanciful or hypothetical. Several others have been formed on the same principle. For instance, the river Elbe in Slavonic was termed Labe, and, by a similar combination, the tribes who inhabited its banks were called Po Labæ or *Polabæ*. The reader, however, must judge for himself which of these conjectures is the more probable. To the latter Frederick the Great has given the sanction of his authority in the treatise entitled Memoirs of the House of Brandenburg.

The ancient inhabitants. The original inhabitants of Prussia were the Slavi or Sarmatæ, in the east and north-east; the Vandals on the shores of the Baltic, to the north of Pomerania; and the Suevi in the remainder of the kingdom. These people, particularly the first, are represented as having been extremely savage and barbarous; living upon raw flesh, and drinking, even to intoxication, the blood of horses at their feasts. They seem to have been unacquainted with the method of constructing huts, and to have lived in caves or under the shelter of rocks and trees, where they protected themselves and their children from the inclemencies of the weather. Such rude tribes cannot be expected to furnish materials for history; and hence little is known respecting them until the thirteenth century, when the Teutonic knights first obtained a footing in the country.

The Teutonic knights. This celebrated fraternity is more or less known to every reader. After the death of Barbarossa, the Germans behaved with so much bravery in the Holy Land, that the king of Jerusalem, the patriarch, and other princes, rewarded their valour by conferring upon their order certain privileges. The body in question was thus instituted under the most favourable auspices. The members were originally called Knights of St George; but they were afterwards denominated *Equites Mariani*, or Knights of St Mary. In the year 1190, they elected Henry Walpol, a German, who had distinguished himself for conduct and bravery, as their first grand-master; and in the subsequent year Pope Celestine III. confirmed to them the privileges which they already enjoyed, and conferred on them the title of Knights of the Teutonic Order, an appellation by which they afterwards became so famous. On the expulsion of the Christians from the Holy Land by Saladdin, a settlement was given to these knights in Prussia by Conrad duke of Mazovia, the competitor of Boleslas V. for the crown of Poland. Their original residence in the former country was Culm, to which territory they were confined by the conditions of the grant, excepting what they might conquer from their pagan neighbours, all which the emperor granted to them in perpetuity. Encouraged by this grant, the knights conquered the greater part of the country now called *Prussia*; and, not content with this, they became so troublesome to Poland, that the monarchs of that kingdom were sometimes obliged to carry on dangerous and bloody wars with the order. (See the article POLAND.) History.

The Teutonic order continued in Prussia until the year 1531. Their last grand-master was Albert marquis of Brandenburg, and nephew of Sigismund I. king of Poland. He was preferred to this dignity in hopes that his affinity to Sigismund might procure a restitution of some of the places which had been taken from the order during the previous unsuccessful wars with Poland; but in this the fraternity were disappointed. Albert, however, was so far from endeavouring to obtain any favour from his uncle by pacific means, that he refused to do homage to him, and immediately began to make preparations for throwing off his dependence, and recovering by force of arms the whole of Prussia and Pomerania. But he was so far from succeeding in his design, that, foiled in every attempt, he was forced to resign the dignity of grand-master; and in recompense for divesting himself of this office, his uncle bestowed on him part of Prussia in quality of secular duke. It was now the interest of the house of Brandenburg to assist in the expulsion of the fraternity; and accordingly, the knights, being at last driven out of Prussia and Pomerania, transferred their chapter to Mariendal in Franconia; but in that and in other provinces of the empire where they settled, little more than the name of the order now remains.

History of Brandenburg. The electorate of Brandenburg, like other parts of Germany, was anciently possessed by barbarians, of whom no accurate account can be given. They were subdued by Charlemagne, as has been related in the history of France (see the article FRANCE, part first); but being on every occasion ready to revolt, Henry the Fowler, in 927, established margraves, or governors of the frontiers, in order to keep the barbarians in awe. The first margrave of Brandenburg was Sigefroy, brother-in-law of the emperor, under whose administration the bishoprics of Brandenburg and Havelberg were established by Otho I. From the time of this Sigefroy, till the succession of the house of Hohenzollern, from whom the present family derive their descent, there are reckoned eight different families who have been margraves of Brandenburg; namely, the family of the Saxons, of Walbeck, Staden, Plenck, Anhalt, Bavaria, Luxemburg, and Misnia. The margraves of the first four races carried on continual wars with the Vandals and other barbarous tribes; nor could their ravages be stopped till the reign of Albert surnamed the Bear, the first prince of the house of Anhalt, who was appointed margrave by the Emperor Conrad III., and afterwards raised to the dignity of elector by Frederick Barbarossa, about the year 1100. Some years afterwards, the king of the Vandals having died without issue, left the Middle March by his last will to the elector, who was besides possessed of the Old March, Upper Saxony, the country of Anhalt, and part of Lusatia. In the year 1332 this line became extinct, and the electorate devolved to the empire. It was then given by the Emperor Louis of Bavaria to his son Louis, who was the first of the sixth race. Louis the Roman succeeded his brother; and as he also died without children, he was succeeded by Otho, his third brother, who sold the electorate to the Emperor Charles IV. of the house of Luxemburg, for two hundred thousand florins of gold. Charles IV. gave the March to his son Winceslas, who was succeeded by Sigismund; and this elector, being embarrassed in his circumstances, sold the New March to the knights of the Teutonic order. Josse succeeded Sigismund; but aspiring to the empire, he sold the electorate to William duke of Misnia, who, after possessing it for one

History. year, sold it again to the Emperor Sigismund. In 1417, Frederick VI. burgrave of Nuremberg, received at the Diet of Constance the investiture of the country of Brandenburg from the hands of the Emperor Sigismund, who, two years previously, had conferred upon Frederick the dignity of elector, and arch-chamberlain of the Holy Roman empire.

This prince, the first of the family of Hohenzollern, one of the oldest in Europe, found himself possessed of the Old and the Middle March; but the dukes of Pomerania had usurped the March of the Ukraine. The elector therefore declared war against them, and soon recovered the province. But as the New March still remained in the hands of the Teutonic knights, to whom it had been sold, as already mentioned, the elector, to compensate for this, took possession of Saxony, which at that time happened to be vacant by the death of Albert, the last elector of the Anhalt line. The emperor, however, disapproving of this step, gave the investiture of Saxony to the Duke of Misnia, upon which Frederick voluntarily desisted from his acquisitions. This elector made a division of his possessions by will. To his eldest son, who had too closely applied himself to the search of the philosopher's stone, he left only Voightland. The electorate was given to his second son Frederick; Albert, surnamed Achilles, received the duchies of Franconia; and Frederick, surnamed the Fat, had the Old March, which, by his death, returned to the electorate of Brandenburg.

Frederick I. was succeeded by his son, called also Frederick, and surnamed Irontooth on account of his strength. He might with as much reason have been surnamed the Magnanimous, since he refused two crowns, that of Bohemia, which was offered him by the pope, and the kingdom of Poland, to which he was invited by the people; but Frederick declared he would not accept of the latter unless Casimir, brother of Ladislas, the late king, should refuse it. These instances of magnanimity had such an effect on the neighbouring people, that the states of Lower Lusatia made him a voluntary surrender of their country. But as Lusatia was a fief of Bohemia, the king of that country immediately made war on the elector, in order to recover it. In this, however, he was so far from being successful, that, by a treaty of peace concluded in 1462, he was obliged to surrender to the elector the perpetual sovereignty of Corbus, Peits, Sommerfeld, and some other places. Frederick having redeemed the New March from the Teutonic order for the sum of a hundred thousand florins, and having still further enlarged his dominions, resigned the sovereignty to his brother Albert, in the year 1469.

Exploits of Albert. Albert was fifty-seven years old when his brother resigned to him the electorate. Most of his exploits had been performed whilst he was burgrave of Nuremberg. Having declared war against Louis duke of Bavaria, he defeated that prince and took him prisoner. He also gained eight battles against the Nurembergers, who had rebelled and contested his rights to the burgraviate. In one of these he fought singly against sixteen men, until his people came up to his assistance. He made himself master of the town of Greiffenburg in the same manner as Alexander the Great took the capital of the Oxydracæ, by leaping from the top of the walls into the town, where he defended himself singly against the inhabitants until his men forced the gates and rescued him. The confidence which the Emperor Frederick III. placed in him, gained him the direction of almost the whole empire. He commanded the imperial armies against Louis the Rich, duke of Bavaria; and also against Charles the Bold, duke of Burgundy, who had laid siege to Nuis, but concluded a peace at the interposition of Albert. He gained the prize at seventeen tournaments, and was never dismounted. All these exploits, however, had been performed before Albert obtained the electorate.

From that time we meet with no very important transactions until the year 1594, when John Sigismund of Brandenburg, having married Anne, the only daughter of Albert duke of Prussia, that duchy was united to the electorate, of which it has ever since formed part; and he also obtained pretensions to the countries of Juliers, Berg, Cleves, Marck, Ravensburg, and Ravenstein, of which Anne was the heiress. History.

Sigismund died in the year 1619, and was succeeded by his son George William, during whose government the electorate suffered great calamities. At this time commenced the war between the Protestants and Catholics, which, from the period of its endurance, has been denominated the Thirty Years' War. The former, although leagued together, were on the point of being utterly destroyed by the imperialists under the command of Tilly and Wallenstein, when Gustavus Adolphus of Sweden turned the scale in their favour, and threatened the Catholic party with total destruction. But by the death of the king on the field of battle at Lutzen, the fortune of war was once more changed. At last, however, peace was concluded with the emperor; and, in 1640, the elector died, leaving his dominions to his son Frederick William. Reign of the elector George William.

That of Frederick William. This young prince, though only twenty years of age at the time of his accession, applied himself with the utmost diligence to repair the losses occasioned by the wars which had preceded. He received the investiture of Prussia personally from the king of Poland, on condition of paying a hundred thousand florins annually, and not making peace with the enemies of that country. His envoy likewise received the investiture of the electorate from the Emperor Ferdinand III. The elector then thought of recovering his provinces from those who had usurped them. He concluded a truce of twenty years with the Swedes, who evacuated the greater part of his states. He likewise paid a hundred and forty thousand crowns to the Swedish garrisons, which still possessed some of his towns; he concluded a treaty with the Hessians, who delivered up a part of the duchy of Cleves; and he obtained of the Hollanders the evacuation of several other cities.

Treaty of Westphalia. In the mean time, the powers of Europe began to be sickened of a war which had continued for such a length of time with unrelenting fury. The cities of Osnaburg and Munster being chosen as the most proper places for negotiation, the conferences were opened in the year 1645; but, by reason of the multiplicity of business, they were not concluded till two years afterwards. France, which had espoused the interests of Sweden, demanded that Pomerania should be ceded to the latter, as an indemnification for the expenses which the war had cost Gustavus Adolphus and his successors. Although the empire and the elector refused to give up Pomerania, it was at last agreed to cede to the Swedes Hither Pomerania, the isles of Rugen and Wollin, and also some cities; in return for which, the bishoprics of Halberstadt, Minden, and Kamin were secularized in favour of the elector, and he was put in possession of them, together with the lordships of Hochenstein and Richenstein, and the reversion of the archbishopric of Magdeburg. Thus was concluded, in 1648, the treaty of Westphalia, which serves as a basis to all the possessions and rights of the German princes. The elector then concluded a treaty with the Swedes for the regulation of limits, and for the acquittal of certain debts; and next year the electorate, Pomerania, and the duchies of Cleves, were evacuated by the Swedes.

Proceedings against the Swedes. Peace. Notwithstanding these treaties, however, the Swedes soon afterwards invaded Pomerania, but were entirely defeated by the elector near the town of Fehrbellin. Three thousand were left dead on the field, amongst whom were a number of officers; and a great many were made prisoners. The elector immediately pursued his victory, and, gaining many advantages over the Swedes, deprived them of the cities of

History. Stralsund and Greiphswald. The Swedes, however, hoping to oblige the elector to evacuate Pomerania, which he had almost totally subdued, invaded Prussia at the head of sixteen thousand men, who advanced from Livonia, and entering the country, burned the suburbs of Memel, and took the cities of Tilse and Insterburg. The elector, to oppose the invaders, left Berlin on the 10th of January 1679, at the head of about nine thousand men. The Swedes retired at his approach, and were much harassed by the troops on their march, losing almost one half their army. At last, having crossed the bay of Frisch-Haff and Courland on the ice, the elector, on the 19th of January, arrived with his infantry within three miles of Tilse, where the Swedes had established their head-quarters. The same day, General Trefenfeldt defeated two regiments of the enemy near Splitter; and the Swedes who were in Tilse having abandoned the place, retired towards Courland. They were pursued by General Gortz, and entirely defeated with great slaughter, so that scarcely three thousand of them returned to Livonia. Yet, notwithstanding these victories, the elector, being pressed on the other side by Turenne and the Prince of Condé, was obliged to make peace with the Swedes. The conditions were, that the treaty of Westphalia should serve as the basis of the peace; and that the elector should have the property of the customs in all the ports of Further Pomerania, with the cities of Kamin, Gartz, Greiffenburg, and Wildenbruck; whilst, on his part, he consented to give up to the Swedes all that he had conquered from them, and to afford no assistance to the king of Denmark, upon condition that France should deliver up to him his provinces in Westphalia, and pay him three hundred thousand ducats as an indemnification for the damages done by the French to his states. This treaty was styled the peace of St Germains.

With the treaty of St Germains terminated the military exploits of Frederick William, who passed the last years of his administration in tranquillity. Few sovereigns ever attained greater celebrity, or enjoyed more fully the affections of his subjects and the respect of foreign countries. An embassy was sent him by Murad Geray, the khan of the Tartars, soliciting his friendship; and he received other marks of the estimation in which he was held. In 1684, he admitted into his dominions great numbers of Protestants who had fled from France after the revocation of the edict of Nantes by Louis XIV.; twenty thousand of whom are said to have settled in the electorate, where they introduced those arts and manufactures which proved of the utmost benefit to the country. Before his time, Prussia was held as a fief of Poland; but in 1656 he compelled the Polish monarch to declare it an independent state. Puffendorf thought the life of this prince a subject not unworthy of his pen; and Frederick the Great regards him[1] as the principal founder of the power and influence of the house of Brandenburg.

Prussia erected into a kingdom. Frederick I.

In 1688, the elector Frederick William died, and was succeeded by his son Frederick III. This prince was remarkably fond of show and ceremony, which, during the course of his government, involved him in great expense. The attainment of the regal dignity seemed to be the great object of his ambition. To accomplish this object, he joined with the emperor in the alliance against France, in which he was engaged by William III. king of Britain. He also yielded up the circle of Schwibus, which had been given to his predecessor; and, in 1700, he obtained from the emperor the royal dignity which he had so earnestly desired. The terms on which it was obtained were, that Frederick should never separate from the empire those provinces of his dominions which depended on it; that he should not, in the emperor's presence, demand any other marks of honour than those which he had hitherto enjoyed; that the ministers which he sent to Vienna should be treated like those of other crowned heads; that the elector should maintain at his own expense six thousand men in Italy, in case the emperor should be obliged to make war by reason of the succession of the house of Bourbon to the crown of Spain; and that the troops in question should continue there whilst the war lasted. History.

Such were the principal terms upon which Prussia was erected into a kingdom, through the friendship of the emperor, with whom Frederick I. (so called as being the first king of Prussia), continued all his life in strict alliance. He was a pacific and patriotic prince; and having always preserved his dominions in peace, consulted more effectually the true interest of his subjects than those monarchs who have dazzled the world by the splendour of their military exploits.

Frederick II.

Frederick I. died in the beginning of 1713, and was succeeded by his son Frederick William, sometimes called Frederick II. He was in almost everything the reverse of his father. His dispositions being altogether martial, he applied himself entirely to the augmentation of his army, and perfecting them in their exercises, by which means they became the most expert soldiers in Europe. His foible was an ambition of having his army composed of men above the ordinary size; but as these could not be procured, he composed a regiment of the tallest men he could find; and as his officers made no scruple of picking up such men wherever they could find them for his majesty's use, the neighbouring states were frequently offended, and a war was often likely to ensue from this ridiculous cause. However, his Prussian majesty never engaged in any martial enterprise of consequence; but having placed his army on the most respectable footing of any in the world, and filled his coffers with cash, for he was of a very saving disposition, he put it in the power of his son to perform those exploits which proved matter of astonishment to all Europe.

In this king's reign Prussia first perceived that her natural enemy and rival was the house of Austria, and not France, as had been formerly supposed. Hence frequent disputes took place between these two powers, for which the persecution of the Protestants by some of the Catholic states of the empire afforded a pretence; and although a war never actually took place, yet it was easy to perceive that both were at heart mortal enemies. But when Frederick William died in 1740, this enmity broke out in full force.

Frederick the Great.

This king was succeeded by his son Frederick III., commonly styled Frederick the Great, who ascended the throne in 1740. He was born on the 24th of January 1712, and in his infancy intrusted to the care of Madame de Rocoule, who spoke no language but French, and thus probably inspired him at once with a taste for that language and a dislike of the German. As he advanced in years, he was put under more accomplished tutors; but as his father's object was to inspire him with a love of military glory, and to teach him the art of war in all its departments, he at first made little progress in science and literature; and, in fact, his erudition was at the best but limited. The branches in which he excelled were the belles lettres and ethics. He was also an adept in music, of which he was passionately fond. But his father not reckoning such an accomplishment compatible with the profession of a soldier, forbade him to cultivate it; and his disobedience of the paternal restriction was the cause of the misunderstanding which existed between him and his father till the death of the latter. Finding himself disgraced at court, he retired to the castle of Rheinsberg, where he devoted his time to study, and to the society and

[1] See Memoirs of the House of Brandenburg.

History. conversation of learned men of different countries. When he ascended the throne in 1740, he was welcomed by the unanimous acclamations of his subjects, who entertained sanguine hopes of his future greatness and celebrity. In accordance with the uniform policy of his family, the early and great object of his life was to increase his dominions; and the first step he took in the accomplishment of this object was the invasion of Silesia upon the death of the emperor of Germany. The empress-queen was placed in a very disagreeable situation by the demise of her father; and of this Frederick took the advantage to do himself justice, as he said, with regard to Silesia, of which his ancestors had been unjustly deprived. The province in question he accordingly seized; but it cost him dear; for the empress, having at last overcome all difficulties, formed against him the most powerful combination that was ever known in Europe.

Combination against him. The treaty by which the empress reluctantly yielded up to the king of Prussia the province of Silesia, and with it a clear revenue of L.800,000 a year, had scarcely been concluded, when she entered into another with the court of St Petersburg, which was concluded on the 22d of May 1746. This treaty, as far as it was made public, was merely of a defensive nature; but six secret and separate articles were added to it. By one of these it was provided, that in case his Prussian majesty should attack the empress-queen, or the empress of Russia, or even the republic of Poland, it should be considered as a breach of the treaty of Dresden, by which Silesia had been given up. It was also stipulated, that notwithstanding that treaty, which, in fact, had been dictated by the king of Prussia himself, the right of the empress-queen to Silesia still continued, and for the recovery of that province the contracting powers engaged mutually to furnish an army of sixty thousand men. To this treaty, called the treaty of St Petersburg, the king of Poland was invited to accede; but being in a manner in the power of the king of Prussia, he did not think proper to sign it. However, he verbally acceded to it, so as to convince the other parties of his design to co-operate in all their measures; and in consideration of such intention, it was agreed that he should have a share in the partition of the king of Prussia's dominions, in the event of the successful issue of their enterprises.

Invasion of axony. In consequence of these machinations, every art was used to render the king of Prussia personally odious to the empress of Russia; the empress-queen made vast preparations in Bohemia and Moravia; and the king of Poland, under pretence of a military amusement, drew together sixteen thousand men, with whom he occupied a strong post at Pirna. The empress-queen, still further to strengthen herself, concluded a treaty with the court of France, dated at Versailles on the 1st of May 1756. In the mean time the king of Prussia, understanding from his emissaries what was going forward, resolved to be beforehand with his enemies; and, to keep the war out of his own country, he entered Saxony with a considerable army. At first he affected only to demand a free passage for his troops, and an observance of the neutrality professed by the king of Poland; but having good reasons to doubt this neutrality, he demanded, as a preliminary, that the Saxon troops should immediately abandon the strong post they occupied, and disperse themselves. This demand being refused, Frederick blockaded the Saxon camp at Pirna, resolving to reduce it by famine, since its strong situation rendered an attack dangerous. At that time there were in Bohemia two Saxon armies; one under the command of Marshal Brown, and the other under that of General Picolomini. To keep these in awe, the king had sent Marshal Schwerin with an army into Bohemia, and Marshal Keith penetrated into the same kingdom on the side of Misnia. But still the king of Prussia did not entirely confide in these dispositions; and therefore fearing lest Brown might afford some assistance to the Saxons, he joined his forces under Keith, and on the 1st of December 1756 attacked and defeated the Austrian general at Lowositz. The latter thus found it impossible to relieve the Saxons, and, after a vain attempt to retire from their post, they were all taken prisoners. The king of Poland quitted his dominions in Germany, and the Prussians took up their winter-quarters in Saxony. Here they seized upon the revenues, levied contributions, and obliged the country to supply them with recruits. At the same time the king of Prussia made himself master of the archives of Dresden, by which means he procured the originals of those documents which, when produced to the world, showed the combination that had been formed against him, and consequently justified the measures he had taken in his own defence.

The king put to the ban of the empire. No sooner had the king entered Saxony in the manner already related, than a process was commenced against him in the Aulic Council, and before the Diet of the Empire, where he was soon condemned for contumacy, and put to the ban of the empire. The various circles were then ordered to furnish their respective contingents of men and money to put this sentence in execution; but these came in so slowly, that, had it not been for the assistance of the French under the Prince de Soubise, the army would probably have never been in a condition to act. The Austrians, in the mean time, made great preparations, and raised a hundred thousand men in Bohemia, whom they placed under the command of Prince Charles of Lorraine, assisted by Marshal Brown. The Czarina sent a body of sixty thousand men under Apraxin to invade ducal Prussia, whilst a strong fleet was equipped in the Baltic to cooperate with that army. The king of Sweden also acceded to the confederacy, in hopes of recovering those possessions which his ancestors had enjoyed in Pomerania; and the Duke of Mecklenburg followed the same course, promising to join the Swedish army with six thousand men as soon as it should be necessary. On the side of the king of Prussia appeared nobody excepting an army of between thirty and forty thousand Hanoverians commanded by the Duke of Cumberland; and these were outnumbered and forced to yield to a superior army of French commanded by D'Etrées.

Invasion of Bohemia, and defeat of the Austrian army. In the mean time, his Prussian majesty, finding that he must depend for assistance solely upon his own abilities, resolved to make the best use of his time. Accordingly, in the spring of 1757, his armies poured into Bohemia from two different points, whilst the king himself prepared to enter it by a third. Marshal Schwerin entered from Silesia, and the Prince of Bevern from Lusatia, where he defeated an army of twenty-eight thousand Austrians who opposed his passage. As the intentions of the king himself were not known, the Austrians detached a body of twenty thousand men from their principal army to observe his motions. This was no sooner done than the king cut off all communication between the detachment and the main body; and having joined his two generals with incredible celerity, he engaged the Austrians near Prague, totally defeated them, and took their camp, military chest, and cannon; but he lost the brave Marshal Schwerin, who was killed at the age of eighty-two, with a colonel's standard in his hand. On the Austrian side Marshal Brown was wounded, and died in a short time, though it is supposed more from the chagrin he suffered than from the dangerous nature of the wound itself.

Siege and bombardment of Prague. About forty thousand of the Austrian army took refuge in Prague, whilst the rest fled in different directions. The city was instantly invested by the king, and all succours were cut off. The great number of troops which it contained made an attack unadvisable, but seemed to render inevitable its reduction by famine; however, the king, to accomplish his purpose the more speedily, prepared to bombard the town. On the 29th of May, after a most dread-

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ful storm of thunder and lightning, four batteries began to play upon the city. From these were thrown every twenty-four hours, 288 bombs, besides a vast number of red-hot balls, so that it was soon on fire in almost every quarter. The garrison made a vigorous defence, and one well-conducted sally, which, however, was repulsed with great loss. The magistrates, burghers, and clergy, seeing their city on the point of being reduced to an heap of rubbish, earnestly supplicated the commander to capitulate; but he was deaf to their entreaties, and drove twelve thousand of the most useless mouths out of the town, who were quickly driven in again by the Prussians.

Count Daun. Battle of Kollin.

The affairs of the empress-queen seemed thus to be verging to destruction, when Leopold count Daun took upon him the command of the army. This general, having arrived within a few miles of Prague on the day after the great battle there, immediately collected the scattered fugitives with the greatest diligence, and retired with them to a strong post in the neighbourhood, whence he gave the troops in Prague hopes of speedy relief. It was now the king of Prussia's business, either to attempt making himself master of the city by one desperate effort, or entirely to abandon the enterprise, and drive Daun from his position before his troops had recovered from the terror of their late defeat. But, by attempting to do both, he rendered himself incapable of doing either. Though the army of Daun already amounted to sixty thousand men, and though they were strongly intrenched, and defended by a vast train of artillery, his majesty thought proper to send against them no more than thirty-two thousand men. On the morning of the 18th of June, the Prussians marched by the left along the great road which leads from Prague to Kollin, intending to assail the enemy's right wing as soon as the necessary dispositions had been made for the attack, and the flank sufficiently developed; but various circumstances conspired to render ineffectual the plan which Frederick had formed. Daun had drawn up his army in order of battle upon the very ground which the Prussians intended to occupy, and the flank movement of the latter, being executed too close to the enemy's line, indeed within the range of their artillery, was arrested, at the critical moment, by several brigades stopping to return the enemy's fire. This effectually deranged the whole combination; and though the Prussians did all that human courage and steadiness could do in the circumstances, and the king himself at last charged at the head of his cavalry, they were driven from the field with a loss in killed, wounded, and missing, of nearly fourteen thousand men of all arms.[1]

Siege of Prague raised.

The immediate consequence of the battle of Kollin was, that the king found himself obliged to raise the siege of Prague, and to take refuge in Saxony. The Austrians harassed him as much as possible in his retreat from Bohemia; but, notwithstanding their superiority, they could not make any decisive attempt against him, as the frontiers of Saxony abounded with positions easily defended. In the mean time the Russians, who had hitherto been very dilatory in their movements, began to exert themselves, and entered Prussia under Apraxin and Fermor, where they committed innumerable cruelties and excesses. A large body of Austrians also entered Silesia, penetrated as far as Breslau, and then laid siege to Schweidnitz; whilst another body entered Lusatia, and made themselves masters of Zittau. An army of twenty-two thousand Swedes also entered Prussian Pomerania, took the towns of Anclam and Demmcin, and laid the whole country under contribution. The French, too, being freed from all restraint by the capitulation of the Duke of Cumberland at Closter-Seven, made their way into Halberstadt and the Old March of Brandenburg, first exacting contributions, and then plundering the towns. The army of the empire, being reinforced by that of the Prince de Soubise, at length marched to occupy Saxony, and thus left the Austrians at liberty to exert the greater part of their force in the reduction of Silesia.

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Berlin laid under contribution. Defeat of Lehwald.

General Haddick penetrated through Lusatia, passed by the Prussian armies, and suddenly appeared before the gates of Berlin, which city he laid under contribution. He retired on the approach of a body of Prussians; yet he still found means to occupy such a position as interrupted the king's communications with Silesia. The destruction of the king of Prussia therefore seemed to be inevitable. Every exertion which he had made, though able and well conducted, had been unsuccessful. His general, Lehwald, who opposed the Russians, had orders to attack them at all events. He obeyed his instructions, and with thirty thousand men attacked sixty thousand of the enemy strongly intrenched at a place called Norkitten. The Prussians behaved with the greatest valour; but after having killed five times more of the enemy than they themselves lost, they were compelled to retire, although more formidable after their defeat than the Russians after their victory. The king, in the mean time, exerted himself on every side, and his enemies fled everywhere before him; but whilst he pursued one body, another gained upon him in an opposite direction, and the winter fast approached, whilst his strength decayed, and that of his adversaries seemed to increase in every quarter.

Battle of Rosbach.

The Prussian monarch, however, though beset with the greatest difficulties, did not abandon himself to despair, or lose that wonderful presence of mind which so eminently distinguished him in all his military enterprises. He purposely delayed a decisive action until the approach of winter, when at length, upon the 5th of November 1757, he, after a variety of skilful movements, encountered at Rosbach the united army of his enemies, commanded by the Prince of Saxe-Hilburghausen and the Prince de Soubise. The allied army amounted to fully fifty thousand men, but most of the troops of the Circles were newly raised, and many of them not well affected to the cause. The Prussians did not exceed twenty-five thousand men; but they were superior to any troops in the world, and inspired, by the presence of their king, with the most enthusiastic valour. The imperialists were attacked whilst in full march, their cavalry was overthrown at the first shock; and being thus prevented from forming a regular order of battle, or bringing their battalions into action except in succession, they were defeated with the loss of three thousand killed, eight generals, two hundred and fifty officers of different ranks, and six thousand private soldiers taken prisoners. Night alone prevented the total destruction of the allied army.

Battle of Breslau.

By this battle the king was set free from the enemy on one side; but this only gave him an opportunity of renewing his efforts on another. The Austrians had collected a great force, and now began to make proportional progress in Silesia. After a siege of sixteen days, they had reduced the strong fortress of Schweidnitz, and obliged the Prussian garrison of four thousand men to surrender as prisoners of war. Hearing of the victory at Rosbach, and learning that the king of Prussia was in full march to relieve Silesia, they resolved to assault the Prince of Bevern in his strong camp under the walls of Breslau. The attempt was made on the 22d of November; but their attack was sustained with the greatest resolution. The slaughter of the Austrians was prodigious. A great part of the enemy had retired from the field of battle, and the rest were preparing to follow their example, when all at once the Prussian general took the same resolution. His army had suffered much in the engagement, and he became apprehensive of a total defeat in case the intrenchments should in any part be forced; for which reason he quitted his strong position and retired be-

[1] See Jomini, *Traité de Grande Tactique*, vol. ii. chap. 10.

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hind the Oder. Two days afterwards, the Prince of Bevern, going to reconnoitre without an escort, attended only by a groom, was taken prisoner by an advanced party of Croats, a small body of whom had crossed the Oder.

Breslau taken by the Austrians.

Upon this the town of Breslau immediately surrendered; and there, as well as at Schweidnitz, the Austrians found great quantities of provisions, ammunition, and money. In fact, all Silesia was on the point of falling into their hands, and the Prussian affairs were fast getting into the utmost distraction, when the king, by a rapid and able march, passed through Thuringia, Misnia, and Lusatia, in spite of the utmost efforts of Haddick and Marshal, who were sent to oppose him, and, entering Silesia upon the 2d of December, joined the Prince of Bevern's corps, which repassed the Oder to meet him. The garrison of Schweidnitz, who, as we have already observed, had been made prisoners of war, also joined the king's army unexpectedly; and their presence contributed not a little, notwithstanding the smallness of their number, to raise the spirits of the whole army. They had submitted with the greatest reluctance; but as the Austrians were conducting them to prison, they happened to receive intelligence of the victory at Rosbach, upon which they immediately rose on the escort that conducted them, and entirely dispersed it; and afterwards marching in such a direction as they thought would most readily lead them to their king, they accidentally met with his army.

Daun defeated at Leuthen.

His Prussian majesty now approached Breslau; on which the Austrians, confiding in their superiority (for they exceeded seventy thousand, whilst the Prussians scarcely amounted to thirty-six thousand), abandoned their strong camp, which the Prince of Bevern had formerly occupied, and advanced to give him battle. The king did not intend by any means to disappoint them, but on his part advanced with the greatest celerity. The two armies met on the 5th of December, near the village of Leuthen. Marshal Daun made the best dispositions possible. The position occupied by his army was a plain, with small eminences, which he covered with artillery; and as the ground was also interspersed with thickets, the Austrians sought to turn these likewise to their advantage. On their right and left were hills, upon which they planted batteries of cannon. The ground in their front was intersected by many causeways; and, to render the whole more impracticable, the Austrians had felled a great number of trees, and scattered them in the way. At the commencement of the engagement it was found almost impossible for the Prussian cavalry to act, on account of these impediments; but in consequence of a judicious disposition made by the king himself, all difficulties were overcome. His majesty, foreseeing that General Nadasty, who was placed on the enemy's left with a corps de reserve, designed to assail him in flank, had placed four battalions immediately behind the cavalry of his right wing, to support them in case of attack. No disposition could have been more fortunate. It happened just as the king had foreseen. Nadasty's cavalry attacked the Prussian right wing with great fury; but they were received with such a severe fire from the four battalions above mentioned, that they were obliged to retire in disorder. The king's flank, then, well covered and supported, was enabled to act with such order and vigour as repulsed the enemy. The Austrian artillery was also silenced by that of the Prussians. Still the Austrians continued to make a gallant resistance during the whole of the battle. After having been thrown into disorder, they rallied all their forces about Leuthen, which was defended on every side by intrenchments and redoubts. The Prussians attacked them with the utmost impetuosity, and at last became masters of the position; upon which the enemy fled on all sides, and a total rout ensued. In this battle the Austrians lost six thousand men killed on the spot, fifteen thousand taken prisoners, and upwards of two hundred pieces of cannon.

The consequences of this victory were very great. Breslau, being immediately invested, surrendered on the 29th of December, and the garrison, amounting to thirteen thousand men, were made prisoners of war. The blockade of Schweidnitz was likewise formed, whilst detached Prussian parties overran the whole country of Silesia, and reduced every place of importance. Meanwhile the Russians, having ravaged and destroyed the country in such a manner that they could not subsist in it, thought proper to retire from the Prussian dominions. General Lehwald being thus left at liberty to act against the Swedes, quickly drove them out of Prussian Pomerania, the whole of which he recovered, and also overran some part of Swedish Pomerania. The duchy of Mecklenburg being thus left quite exposed, the king took ample vengeance on it, by exacting severe contributions of men and money. To complete this monarch's good fortune, the French, who had retired after the battle of Rosbach, were now opposed by the Hanoverians under Prince Ferdinand, who kept them so well employed that, during the remainder of the war, the king of Prussia had no more trouble from them.

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Breslau retaken.

Schweidnitz retaken. Siege of Olmutz.

The beginning of the year 1758 proved favourable to the arms of his Prussian majesty. On the 3d of April he commenced his operations against Schweidnitz, and pushed the siege so vigorously that the place surrendered in thirteen days. He then disposed his forces in such a manner as might best guard his dominions against his numerous enemies. For this purpose Count Dohna commanded a body of troops on the side of Pomerania; whilst another considerable body was posted between Wohlau and Glogau, in order to cover Silesia from the Russians, in case they should make their inroad that way. A little time afterwards an army was formed in Saxony, commanded by the king's brother, Prince Henry. This army consisted of thirty battalions and forty-five squadrons, and was designed to make head against the army of the Circles, which, by great efforts during the winter, and the junction of a considerable body of Austrians, was again in a condition to take the field. Between all these armies a ready communication was kept up by a regular chain of posts. After the reduction of Schweidnitz, the king, having made a show of invading Bohemia, suddenly burst into Moravia, where in a short time he made himself master of the whole country, and on the 27th of May laid siege to Olmutz, the capital. Of this Daun no sooner got information than he marched to Moravia through Bohemia; and though he was not in a condition to risk a battle, yet, by placing himself in a strong situation, where he could not be attacked, by harassing the king's troops and cutting off their convoys, he at last obliged him to abandon the enterprise. The king, however, who frequently owed much of his success to the impenetrable secrecy in which he shrouded all his designs, gave not the least hint of his intention to raise the siege of Olmutz. On the contrary, the very day before the siege was raised, the firing continued as briskly as ever; but in the night of the 1st of July, the whole army took the road to Bohemia in two columns, and gained an entire march upon the Austrians. Thus, notwithstanding the utmost efforts of his enemies, the Prussian army reached Bohemia, where the king seized upon a large magazine at Lieutomissel; defeated some corps of Austrians who had attempted to interrupt his progress; and arrived at Königsgratz, of which he took possession, after driving from it seven thousand Austrians who were intrenched there. This city and several other districts he laid under contribution; but he soon afterwards entered Silesia, and marched with the utmost rapidity to encounter the Russians, who having united their forces under Brown and Fermor, had entered the New March of Brandenburg, and laid siege to Custrin.

Battle of Zorndorff.

The king arrived in this city at a very critical period. The Russians had laid siege to it on the 15th of August; and though they were not well skilled in managing artillery,

History. yet, by furious and unremitting discharges at random, they threw in such a number of bombs and red-hot balls, that the town was soon on fire in every quarter. Some of the wretched inhabitants were burned; others were buried in the ruins of their houses, or killed by the balls which fell like hail in the streets; whilst many of the survivors abandoned their habitations, and fled out of the town on the side where it was not invested. The governor did everything for the defence of the place; but as the walls were built after the ancient manner, it was impossible that the town could have made a lengthened defence, especially as the principal magazine of the besieged had been blown up. The stern avenger of all these injuries, however, was now at hand. The king came in sight of the Russians on the 25th of August, after a march of fifty-six days, in the course of which he beheld the country everywhere desolated, and the villages in flames. At his approach the enemy raised the siege, and retired towards the neighbouring village of Zorndorff, where they were almost immediately attacked. At nine o'clock in the morning a terrible fire of cannon and mortars poured destruction on the right wing of the Russian army for two hours without intermission. The slaughter was such as might have been expected; but the Russians kept their ground with astonishing resolution, new regiments pressing forward to supply the places of those that fell. When the first line had expended all their ammunition, they rushed forward on the Prussians with their bayonets; and these brave troops, although encouraged by the presence of their king, gave way and fled before an enemy already half defeated. The Russian generals ought now to have attacked with their cavalry the disordered infantry of the enemy, which would have completed the defeat, and in all probability given the finishing stroke to the king of Prussia's affairs. This opportunity, however, they lost. But the king was not so negligent. By a very rapid and masterly movement, he brought all the cavalry of his right wing to the centre, and falling upon the Russian infantry, uncovered by their cavalry, and even disordered by their own success, drove them back with horrible slaughter, at the same time that the repulsed battalions of infantry, returning to the charge, decided the victory. The Russians were now thrown into the most dreadful confusion. The wind blew the dust and smoke into their faces, so that, unable to distinguish friends from foes, they fired on each other, plundered their own baggage, which had been placed between the lines, and intoxicated themselves with brandy; the ranks fell in upon one another, and being thus crammed together into a narrow space, the fire of the Prussians produced dreadful effect, whilst their enemies kept up only a scattered and ineffectual discharge. Yet even in this dismal situation the Russians did not fly, but suffered themselves to be slaughtered till seven in the evening, when their generals having caused an attack to be made on the Prussian right wing, the attention of the enemy was drawn to that quarter, and they had thus time to retire a little from the field of battle to recover their order. In this engagement the Russians lost twenty-one thousand five hundred and twenty-nine men, whilst that of the Prussians did not exceed two thousand. A vast train of artillery was taken, together with the military chest, and many officers of high rank. The consequence was, that the Russian army retreated as far as Landsperg, on the frontiers of Poland, and the king was left at liberty to march with his usual expedition to the relief of Prince Henry in Saxony.

The prince was at this time severely pressed by Marshal Daun. As soon as the king had left Bohemia in the manner already related, Daun, considering it of no use to follow him, resolved to turn his arms against Saxony. Towards that country, therefore, he marched through Lusatia, by Zittau, Gorlitz, and Bautzen. On the 3d of September he invested the strong fortress of Sonnestein, which unaccountably surrendered, after a single day's resistance, to one of his generals, named Macguire. He then directed his movement so as to favour the operations of General Laudon, who had advanced through Lower Lusatia to the confines of Brandenburg; and, by drawing the attention of the Prussian forces which had been left in Silesia to the northward of that duchy, he facilitated the progress of Generals Karsch and Deville in the southern parts. He then proposed that Prince Henry should be attacked by the army of the Circles, whilst that of the Austrians should pass the Elbe, and, falling at the same time on the Prussians, second the attack of the imperialists, and cut off the retreat of their enemies from Dresden. The sudden appearance of the king of Prussia, however, put an end to his plan. General Laudon abandoned all his conquests in Lower Lusatia, and retired towards Daun, whilst that general himself retired from the neighbourhood of Dresden as far as Zittau. The army of the empire kept its ground in the strong position at Pirna, formerly mentioned, but did not undertake any thing. As for the Swedes, who had directed their movements by those of the Russians, they no sooner heard of the victory of Zorndoff than they retreated with much more expedition than they had advanced.

History. Operations of Daun rendered abortive.

The affairs of the king of Prussia seemed to be thus pretty well retrieved, when, by an unfortunate oversight, he was brought to the verge of ruin. Marshal Daun had taken up an advantageous position at Stolpen, by which he preserved a communication with the army of the empire. On the other hand, the king of Prussia, having taken possession of an important post at Bautzen, extended his right wing to the village of Hohenkirchen, by which he preserved a communication with Prince Henry, protected Brandenburg, and had the power, if necessary, of throwing succours into Silesia. The two armies kept a watchful eye on each other's movements; and as the principal aim of Daun was to cut off the king's communication with Silesia, and that of the king to intercept Daun's communication with Bohemia, a battle seemed inevitable. In this posture of affairs the Austrian general formed a design of attacking the Prussian camp in the night; and in point of fact he succeeded, under cover of the darkness, prolonged by a thick mist, in surprising his usually vigilant enemy, who obviously never contemplated such an enterprise on the part of his opponent. Soon after midnight, the Austrian army began its march in three columns towards the camp of the king of Prussia. The night was exceedingly dark, and they had a considerable way to march; yet all the columns arrived simultaneously, without being discovered, or the least confusion having occurred; and at five in the morning they began a regular and well-conducted attack upon one extremity of the Prussian line, which was at the same time taken in reverse by the Austrian left wing formed *en potence*. Nothing could withstand the sudden attack thus made. The battalions, as they hastily formed, were swept away by the overwhelming fire of the Austrians; the Prussians were thrown into confusion; and Marshal Keith, one of their best generals, having received two musket-balls, fell dead on the spot.[1] Prince Francis of Brunswick had his head shot off by a cannon-ball as he was mounting his horse; and everything seemed to

Surprise of the Prussian army at Hohenkirchen.

[1] Frederick's position was not good, and of this he was made fully aware. Two days before the battle, Marshal Keith said to him, "Si les Autrichiens nous laissent dans ce camp, ils méritent d'être pendus." The king, smiling at the observation, replied, "Il faut espérer que Daun aura plus peur de nous que de la corde." This anecdote is eminently characteristic. The king relied on the resources of his genius, and if light, which the ancient hero prayed for when beset by his enemies, had been vouchsafed to Frederick, Daun would never have gathered the bloody and bootless laurels of Hohenkirchen.

History. announce the total destruction of the army. Still, however, the king preserved his wonderful presence of mind, which indeed never forsook him, even on the most trying occasion. He ordered some detachments from his left wing to support the right; but the moment that these orders were received, the left itself was furiously attacked. General Ketzow, who commanded in that quarter, repulsed the Austrians with difficulty, but was not able to afford any considerable assistance to the right, which alone was obliged to sustain the weight of the principal attack. The Austrians, in the beginning of the engagement, had driven the Prussians out of the village of Hohenkirchen; and as the fate of the day depended upon the possession of that post, no effort was spared to recover it. The Prussians made three bloody and unsuccessful attacks on the village; in the fourth they carried it; but the Austrians continually pouring in fresh troops, they were at last driven out with great slaughter. The king then ordered a retreat, which was conducted in good order, without being pursued; nevertheless, this bloody action cost him seven thousand men, together with a great number of cannon. The Austrians computed their own loss at five thousand.

His Prussian majesty, having thus happily escaped such imminent danger, took every possible measure to prevent the enemy from gaining any considerable advantage from his defeat.[1] Perceiving that the only advantage which they wished to derive from it was to cover the operations of their armies in Silesia, and that he had now nothing to fear on the side of Saxony, he reinforced his own army from that of his brother Prince Henry, and hastened into Silesia to raise the siege of Neiss, which had been completely invested on the 4th of October. On the 24th of that month, therefore, he quitted his camp, and by a circuitous route, to avoid obstruction from the enemy, arrived in the plains of Gorlitz. A body of the Austrians had in vain attempted to secure this post before him, and some who arrived after him were defeated with the loss of eight hundred men. From this place the king pursued his march with the utmost diligence, but was followed by Laudon at the head of twenty-four thousand men, who constantly hung upon his rear, and harassed his army. The king, however, knowing the importance of his expedition, continued his march without interruption, and suffered his antagonist to obtain some trifling advantages without molestation. Daun, however, not content with the opposition given by Laudon, sent a large body of horse and foot by another route to reinforce Karsch and Deville, who had formed the siege of Neiss and the blockade of Cosel, whilst he himself passed the Elbe, and advanced towards Dresden.

Suburbs of Dresden burned.

All these precautions, however, were of little avail. Generals Karsch and Deville, notwithstanding their reinforcement, no sooner heard of the king's approach than they raised the siege of both places, and retired, leaving behind them a considerable quantity of military stores. The object of the march being thus accomplished, the king instantly returned, and hastened to the relief of Saxony, the capital of which was in great danger from Marshal Daun. The place was but indifferently fortified, and garrisoned only by twelve thousand men; so that it could not hold out long against a numerous and well-appointed army. It was besides commanded by a large suburb, of which, if once the enemy got possession, all defence of the city would then be vain. For this reason Schmettau, the Prussian governor, determined to set these suburbs on fire, which was actually done on the 10th of November, to the incredible loss of the inhabitants, as in the suburbs were carried on most of those valuable manufactures which render the city of Dresden remarkable. This disappointed the designs of Daun; but, though the act was conformable to the laws of war, and had been executed with all the caution and humanity possible, yet the Austrians exclaimed against it, as a piece of the most unprovoked and barbarous cruelty recorded in history.

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Saxony oppressed by the king of Prussia.

After the king of Prussia had approached Dresden, all the Austrian armies retired into Bohemia, where they took up their winter quarters, as did also the king of Prussia in Saxony. This unhappy country he said he would now consider as his own by right of conquest. But instead of treating the conquered people as his lawful subjects, he oppressed them in all possible ways, by levying the most severe and exorbitant contributions, surrounding the exchange with soldiers, and confining the merchants in narrow lodgings on straw beds, till they drew upon their correspondents for such sums as he wanted.

Operations in Bohemia.

As early as the 23d of February 1759 the Prussians commenced military operations. General Wobersow marched with a body of troops into Poland, where he destroyed several large magazines belonging to the Russians, and returned into Silesia, without any loss, on the 18th of April. In the mean time, by certain movements on the part of the king, the greater part of the Austrian troops had been drawn towards the frontiers of Silesia. Prince Henry immediately took advantage of this opening, and on the 15th of April entered Bohemia with his army divided into two columns. One, commanded by himself, marched towards Peterswalde; the other, under General Hulsen, passed by the towns of Pasberg and Kommotau. That commanded by Prince Henry himself penetrated as far as Loboschutz and Leitmeritz; the enemy flying everywhere before them, and burning or abandoning the vast magazines which they had amassed. The division under General Hulsen had more active employment. A strong pass at Pasberg was defended by a considerable body of Austrians. General Hulsen, having conducted his cavalry by another road, so as to fall directly upon their rear, attacked them in front with his infantry, drove them out of their intrenchments, and totally defeated them with the loss of a great number killed, and two thousand taken prisoners, whilst that of the Prussians did not exceed seventy in killed and wounded. After this exploit they returned into Saxony, with hostages for the contributions which they had freely exacted during the course of their expedition.

Prussians defeated at Zulichau.

Some other successes obtained by Prince Henry cleared Franconia of the enemy; but the approach of the Russians seemed once more to bring the affairs of the king of Prussia to a crisis. Notwithstanding the destruction of their magazines, they had continued to advance into Silesia, where they were opposed by Count Dohna; but as the troops he had under him were far inferior to the enemy, he found it impossible to do more, at least with any appearance of success, than to observe their motions and harass them on their march. This was so displeasing to the

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[1] When Frederick had retired to the camp of Doberschutz, he said to his generals, "Daun nous a laissé sortir de l'échiquier; la partie n'est pas perdue; nous nous reposerons ici, et nous marcherons ensuite en Silésie pour délivrer Neiss." This sally betrays a mind independent of and superior to events. A king who, situated as Frederick then was, preserves coolness enough to compare his operations to a party at chess, the field of desolation which he had just quitted to a chess-board, and his whole existence to the turn of a game, is capable of performing the greatest actions in war. It is such men that triumph over fortune. He had been surprised under circumstances most favourable to the assailant, all of whose movements were completely concealed till the last moment by a dense fog; the extremity of his line had been attacked, and almost at the same instant taken in reverse, by the main body of the Austrian army; yet, in spite of these fearful odds, he maintained the contest for hours with nearly balanced chances, and inflicted such a severe loss on the enemy as deprived him not only of the ability to pursue, but also of the fruits which he might have expected to reap from his victory.

History. king, that he disgraced this general, and appointed Wedel to succeed him, with orders to attack the Russians at all events. To enable Wedel, however, to comply with his desperate order, he sent him some reinforcements, which increased his army to about thirty thousand men. With these, on the 23d of July 1759, Wedel attacked seventy thousand Russians posted in the most advantageous manner at Zulichau, and defended by a numerous artillery. Though the Prussians marched on to almost certain defeat, they sustained the attack for a long time with unparalleled resolution. At last, however, they gave way, and were obliged to retire with the loss of four thousand seven hundred killed or taken prisoners, and three thousand wounded.

Crossen and Francfort on the Oder taken.

The consequences of this victory were, that the Russians penetrated into the Prussian territories, and took possession of the towns of Crossen and Francfort on the Oder, which rendered it absolutely necessary for the king to go in person to oppose them. Accordingly, on the 4th of August he joined Wedel with a considerable body of forces, having left the greater part of his army in Saxony under Prince Henry. But as Marshal Daun had sent to the assistance of the Russians under Soltikof a body of twelve thousand horse and eight thousand foot under General Laudon, the king still found himself unable to fight them, since with this and some other reinforcements their army now amounted to upwards of ninety thousand men. He therefore recalled General Finck, whom he had sent into Saxony with nine thousand men; but with all his reinforcements he found it impossible to augment his army to little more than forty thousand men of all arms. His situation, however, was now so critical that a battle had become inevitable; and therefore, on the 12th of August, with this inferior force, the king attacked his enemies, strongly intrenched, and defended by a prodigious number of cannon.

Battle of Kunersdorf.

In this action his principal effort was directed against the left wing of the Russian army. He began the attack, according to custom, with a heavy cannonade; and having produced the desired effect, he then assailed the left wing with several battalions disposed in columns. The Russian intrenchments were forced with great slaughter, and seventy-two pieces of cannon were taken. But still there was a defile to be passed, and several redoubts which covered the village of Kunersdorf remained to be carried. These were attacked with the same resolution, and one after another taken. The enemy made another stand at the village, and endeavoured to preserve their ground there by pushing forward several battalions of horse and foot; but this also proved unsuccessful, and they were driven from post to post quite to the last redoubts. For upwards of six hours the Prussians were successful, and everywhere broke the enemy with prodigious slaughter; they drove them from almost all the positions they had occupied before the battle, took more than half their artillery, and scarcely anything seemed wanting to render the victory complete. In these circumstances, the king wrote the following billet to the queen: "Madam, we have beaten the Russians from their intrenchments. In two hours expect to hear of a glorious victory." But at this very instant victory abandoned the Prussian standards. The enemy, defeated in almost every quarter, found their left wing, shattered as it was, more entire than any other part of their line. Soltikof, the Russian general, immediately assembled the remains of his right wing, and collecting as many as he could from his centre, reinforced the left, and made a stand at a redoubt which had been erected on an advantageous eminence in a cemetery. All the king's generals are said to have been of opinion that he ought to allow the Russians to retain peaceable possession of this post. Their army had already suffered so much, that it would have been impossible for them to attempt any enterprise of consequence after the battle; besides, their artillery was still numerous, the post was very strong, and the Prussian troops were greatly fatigued. These reasons for a few moments weighed with the king; but the natural impetuosity of his temper getting the better of his reason, he led on his wearied troops to renew the combat. History.

Within the limits to which we are restricted, it is impossible to give any adequate military details of this terrible battle. Suffice it to state, that, wherever the storm of the conflict raged most fiercely, there was the king haranguing the troops, leading in person the battalions to the charge, and exposing himself with all the hardihood of the merest soldier of fortune. The carnage was truly horrible, the combatants mutually discharging showers of grape at the distance of fifty paces, and musketry even closer. The battle had already lasted six hours with inconceivable obstinacy; the Prussians were harassed, and scarcely in a condition to sustain themselves; whilst sixteen thousand men killed or wounded attested their courageous efforts, but deprived them of the means of maintaining the conflict. At this moment some Austrian squadrons charged the right flank of Finck's division; the king, in attempting to cover the retreat, received a contusion, and two battalions were taken behind him. The disorder now became dreadful, and the total destruction of the army was only prevented by that extraordinary presence of mind which had never for a moment failed him, even in the midst of this terrible conflict. Such was the memorable and sanguinary day of Kunersdorf, on which the Prussians lost half their number in killed and wounded, besides a hundred and sixty-five pieces of cannon, abandoned in the battle and the retreat. The loss of the enemy in killed and wounded amounted to sixteen thousand Russians, and three thousand Austrians. Soltikof, in writing to the empress an account of the battle, dryly observed, that "if he gained another such victory, he would himself be obliged to carry the tidings on foot, with a staff in his hand." The king, when he found the victory totally lost, is said to have sent another billet to the queen, expressed in the following manner: "Remove from Berlin with the royal family; let the archives be carried to Potsdam; the town may make conditions with the enemy."

Immediately after this defeat, the king set himself about repairing his losses with the utmost diligence; and in a few days everything was again put in order in his camp. He replaced his artillery from Berlin; recalled General Kleist with five thousand men from Pomerania; detached six thousand from his own army to the defence of Saxony; and with the remainder threw himself between the Russians and Great Glogau, covering that city, which had been the chief object of their designs. In a word, notwithstanding their victory, he obliged the Russians to return to Poland without accomplishing any thing besides the barren victory of Kunersdorff, purchased at so fearful an expenditure of human life.

Surrender of General Finck.

The misfortunes of the Prussian monarch, however, were not at an end. Prince Henry, indeed, by a most extraordinary and well-conducted march, entered Saxony, which had been totally overrun by the armies of the enemy; and strong detachments having been sent into that country under Generals Finck and Wunsch, the whole except Dresden was in a short time recovered. Towards this place Marshal Daun retired, and in all probability he would soon have been obliged to quit Saxony, had Frederick been content with attaining this object. But the king's impatience could not be satisfied without cutting off Daun's retreat, and forcing him to a battle; and for this purpose he sent General Finck, with upwards of twelve thousand men according to the Prussian account, but with twenty thousand according to that of the Austrians, to seize some passes through which alone Daun could make his way towards Bohemia. This commission was executed with the greatest exactness; but the Prussian general, having probably advanced too far into these defiles, and neglected to preserve his communications

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with the main army, gave the enemy an opportunity of surrounding him, and at last forcing him and his whole army to surrender prisoners of war. Nor was it long before this disaster was followed by another. General Durceke occupied a position on the right bank of the Elbe, opposite to Meissen; and on the approach of a large body of Austrians he prepared to retreat across the river, into a place where he hoped to be more secure; but having been obliged by a hard frost to withdraw the bridge of boats, a thaw supervened, and when the Prussians were attempting to lay a bridge of pontoons, their rear-guard was attacked with great fury by the Austrians, and the whole either killed or taken. The loss of the Prussians on this occasion was computed at nearly three thousand men.

Desperate situation of the king of Prussia.

The year 1760 showed the Prussian monarch in a more dangerous situation than he had ever before stood. His affairs, indeed, seemed to be altogether desperate. His losses were not to be measured by the number of the killed or prisoners, but by armies destroyed or taken. Forty generals had died or been slain in his service since the beginning of October 1756, exclusive of those who were wounded or taken prisoners. This of itself would have been an irreparable loss, had not the very wars which destroyed these men furnished others equally capable of filling their places. But another deficiency, which could not be remedied, still remained. The king, by his indefatigable industry and exertions, had supplied all the deficiencies of men in his armies; but they were not the same men as before. The hardy veterans, with whom he had originally taken the field, were now no more, and their places were supplied by others who had neither the same experience nor the same discipline; so that he was obliged to supply the deficiency by his own genius and heroism.

Prussians defeated at Landshut.

But whatever abilities the Prussian monarch might possess, and he undoubtedly exerted them to the utmost, it seemed only to be contending against fate. His enemies gained over him still greater and greater advantages. General Laudon, with whom none but the king himself seems to have been able to cope, by a series of artful movements drew Fouquet, one of the Prussian generals, who commanded a strong body of forces, into a disadvantageous situation near Landshut. Perceiving it impossible for the Prussians to escape, Laudon then attacked their intrenchments on the night of the 23d of June. The Prussians made a gallant defence, but at last were all either killed or taken prisoners, except about three hundred. Of the Prussians four thousand were killed, and seven thousand taken prisoners; fifty-eight pieces of cannon, and a great number of colours, were also lost. The victory, however, was dearly bought; for the Austrians lost in killed and wounded above twelve thousand men, whom, however, they could better spare than the Prussians, on account of their great superiority of numbers.

Glatz taken by the Austrians.

Laudon failed not to improve this victory to the utmost. He instantly turned back from Landshut, and fell upon the city of Glatz, which he took in a very short time, with the garrison who defended it, consisting of two thousand men. In this place were found a hundred and one pieces of brass cannon, with immense quantities of provisions and military stores. From thence he marched against Breslau, and immediately invested it. But, in the mean while, the king of Prussia, whose motions had been all this time counteracted by Marshal Daun in Saxony, marched with his usual rapidity towards Silesia. By this means he drew Daun out of Saxony; and indeed the Austrian general used such expedition that he gained two days' march on the king. This was no sooner known to his Prussian majesty than he returned with the same expedition as he had advanced, and sat down before Dresden.

Daun soon received intelligence of the king's retrograde movement, and also returned. In the mean time, however, the buildings of the city were terribly shattered by the king's cannon and bombs, which continually played on it. But his endeavours to reduce it before the arrival of Daun proved ineffectual. The siege had been begun on the 13th of July, and on the 19th Daun appeared within a league of Dresden. The Prussians then redoubled their efforts. They had that day received reinforcements of heavy cannon and mortars, with which they battered the place incessantly. The cathedral church, several principal streets, some palaces, and the noble manufactory of porcelain, were entirely destroyed. The siege was continued till the 22d; but on the night of the 21st Daun had thrown sixteen battalions into the city, which rendered it impossible for the king to continue longer before it with any prospect of success. He therefore raised the siege, and retired without molestation, though there were three considerable armies of the enemy in the neighbourhood. Breslau was fiercely bombarded by Laudon; but the approach of Prince Henry obliged him to desist from his enterprise on the 5th of August.

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Dresden besieged without success by Frederick.

The Austrian generals unite their forces against the king.

Meanwhile the fortune of the king seemed likely to be terminated by one fatal stroke. Finding it impossible for him to carry on a defensive war, he marched towards Silesia with such astonishing rapidity, that before the middle of August he had advanced two hundred miles, leaving Marshal Daun with his army far behind him. The object he had in view by using such expedition was to engage Laudon before he could have time to effect a junction with Daun, and Lascy, another Austrian general; a union which seemed to threaten him with unavoidable destruction. This, however, he found it impossible to prevent; and the three armies, when united, formed a tremendous line of encampments, extending no less than thirty English miles, at the same time that every one of their posts was strong, and the communication between them easy. The king was strongly encamped at Leignitz, and for several days employed all his military skill in attempting to induce one of the bodies to detach itself from the rest, or to attack them at some disadvantage; but without the least effect.

Battle of Leignitz.

At last the Austrian generals, having maturely weighed all circumstances, resolved to attack the king's camp itself, strong as it was; and Marshal Daun, remembering the advantage he had gained at Hohenkirchen by an attack in the night-time, resolved to follow a similar plan on the present occasion. The whole army, as soon as it became dark, were to march from their several stations to such positions as were marked out for each corps; they were to strike their tents, but still to keep up the fires in their camps, and to cause the drums to beat the tattoo as usual, by which means they hoped to surprise the enemy; and, even if they failed in this, they judged it impossible for him to escape them, should he be ever so much on his guard. The king, having completed his dispositions for the night, had seated himself and begun to doze near a bivouac fire, when Major Hund, who, with five squadrons of Zeithen's hussars, had been sent in reconnoissance as far as Polschildern, returned at full speed, calling out, "Where is the king? Where is the king?" Frederick having demanded what was the matter, the major said, with an animated air, "Sire, the enemy is *there*," pointing in the direction; "he has repulsed my videttes, and is not more than four hundred paces from this." The king having ordered this officer to retard as much as possible the advance of the Austrians, proceeded to issue orders, and make dispositions for defeating the design of the enemy. He indicated to General Schenkendorf, who commanded the brigade of the extreme left, an eminence situated near Binowitz, on which he was to form; he gave orders to the second line to prolong itself to the left, to prevent the enemy from attacking the army in flank; and he immediately brought to the front several regiments of cavalry, in order to gain the time necessary for the execution of all these dispositions.

History. General Schenkendorf marched immediately by the left flank, gained the hill, and there established a battery of ten twelve-pounders, at the moment when the Austrians were about to occupy the position. The latter, in fact, were so near, that the Prussians opened on them a heavy fire of grape, which caused great havock in the columns, while attempting to form, but unable to do so. As soon as the Prussian army was drawn up, Frederick divided it, leaving his right on the ground where it had been formed, to observe Marshal Daun, and to maintain their post; whilst with his left he turned in order to fall upon the corps under General Laudon. In the mean time, that commander, ignorant of the fate which was awaiting him, advanced with the utmost expedition towards the place which had been assigned him, in order to share in the glory of destroying the Prussian monarch; when, at three in the morning, on the 15th of August, a thick fog which covered the ground suddenly clearing up, discovered, like the opening of a mighty scene, the front of the Prussian army regularly drawn up in order of battle, and advantageously posted. Laudon, though surprised, made the best dispositions that circumstances would admit of, and an obstinate engagement ensued. After five successive attacks, executed by the Prussians, against as many different lines, he at length resolved to yield them the field of battle. It was not quite five in the morning when the battle was decided. It cost the Austrians more than ten thousand men, of whom six thousand were prisoners, and eighty-six pieces of cannon; but the loss of the Prussians did not exceed two thousand men, because all the advantages were clearly on their side.

The king did not venture to pursue Laudon, conceiving that he would require his victorious troops to support his right wing against Daun, and even Lascy. Conformably to his plan, and in order to attack by day-break the right of the camp at Leignitz, the marshal had in the evening of the 14th marched in six columns, intending to approach as far as the Katzbach. A detachment of partisans passed the river at eleven o'clock at night, to dislodge the Prussians from a village which they had occupied on the other bank, but which the enemy's troops were astonished to find they had abandoned. Daun was not apprised of this circumstance until two in the morning, when he gave orders that the army should immediately pass the Katzbach; but this operation, retarded by the darkness, the construction of bridges, and the false direction given to some of the columns, was not effected until five in the morning, when it was no longer time to support Laudon, who had already sustained a defeat. The marshal having learned the fate of his colleague, and observing the firm countenance maintained by the victorious Prussians, retired to his original position between Neudorf and Cosendau.

The victory of Leignitz, though complete, gave but a partial relief to the king of Prussia. The most essential service it did was the preventing the Russians from joining those enemies which he already had before him. Count Czernichef had been advancing with twenty-four thousand men, and had even passed the Oder; but he was so intimidated by the result of this battle, that he instantly repassed that river, even although Daun had sent him a strong body of troops in order to encourage him to advance. Soon after this battle, the king joined his brother Prince Henry, and marching against Daun, who had begun to form the blockade of Schweidnitz, fell upon a corps under General Beck, made two battalions of Croats prisoners, and dispersed the remainder, which obliged the enemy to abandon the enterprise they had just undertaken. About the same time, General Hulsen gained a considerable advantage over the imperial army in Saxony, with very trifling loss on his part; by which he effectually prevented them from cutting off his communications with Torgau.

By these successes the affairs of his Prussian majesty seemed to revive; but his enemies were still formidable and menacing. The recent manœuvres had drawn him so far into Silesia, that his communication with Brandenburg was almost wholly intercepted. The Russian army, which, after it had repassed the Order, began to quit Silesia, sent forward a powerful detachment under Count Czernichef towards the March of Brandenburg. A body of fifteen thousand Austrians, under the generals Lascy and Brentano, and the united body of Austrians and imperialists which acted in Saxony, began their march in concert with the Russians, and proposed to unite at the gates of Berlin. These armies amounted to forty thousand men. To oppose this formidable force, General Hulsen called to his assistance General Werner, who had been detached with a body of troops to Pomerania; but, after being joined by him, their united forces were found not to exceed fifteen or sixteen thousand men. To attempt a defence of the capital with this force would have been little short of madness. These commanders were therefore obliged to leave Berlin to its fate, which, indeed, considering the barbarity of the Russians and the animosity of the Austrians, seemed to be a dreadful one. However, by the powerful mediation of several foreign ministers, the town obtained terms which were not altogether intolerable; but the magazines, arsenals, and founderies were destroyed, and an immense quantity of military stores was seized, with a number of cannon and other arms. The city was first obliged to pay eight hundred thousand guilders, after which a contribution of one million nine hundred thousand crowns was imposed; yet, notwithstanding this, many acts of violence were committed, and the king's palace was plundered, the furniture being abused in a scandalous manner.

History. Berlin taken by the Austrians and Russians.

The combined armies remained only four days in Berlin. Dreading the vengeance of the king of Prussia, who was rapidly advancing, they deemed it prudent to make their stay as short as possible. But so great were the embarrassments which now beset that monarch, that it seemed almost beyond human power to retrieve his affairs. The imperialists, on their return from Berlin, having no army to oppose them, made themselves masters of Leipzig, Torgau, Meissen, and Wirtemberg, in which last city they found the grand magazine of the Prussian army. Stainville also, at the head of a detachment from the French army, laid both the city and duchy of Halberstadt under contribution. In Eastern Pomerania, the Russians had besieged Colberg both by land and by sea. In Western Pomerania, the Swedes advanced with the greatest celerity, hoping to share in the plunder of Berlin. In Silesia, the king no sooner began his march to the northward, than Laudon advanced, and laid siege to the important fortress of Cosel; and, to complete his distress and embarrassment, the king himself was attended at every step by Daun with a superior army, prepared to take every advantage.

Extreme embarrassment of the king.

In this situation the king, being joined by Hulsen and the Prince of Wirtemberg, with the corps under their command, advanced along the Elbe, whilst Daun fell back in order to cover Leipzig and Torgau; but the latter finding that the Prussians directed their march towards the Elbe, encamped within reach of Torgau, one part of his army extending to the Elbe, by which he was protected on one side, whilst on the other he was covered by hills and woods, thus occupying a most advantageous position. The Prussian army did not amount to fifty thousand men, whilst that of the Austrians exceeded eighty-six thousand; yet such were the unfortunate circumstances of the king, that he was obliged to fight under all these disadvantages. He therefore caused his army to be informed that he was now to lead them to a most desperate attempt, that his affairs required it, and that he was determined to conquer or die. His soldiers unanimously declared that they would die with him.

The 3d of November 1760 was the day upon which this important action was fought. The king divided his forces

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Marshal Daun defeated at Torgau.

into three columns. General Hulsen was directed to take post with one in a wood which lay on the left of the Austrian army, with instructions not to move until he found the rest of the Prussians engaged; General Zeithen was to charge with the right; and the grand attack in front was to be conducted by the king in person. His forces were disposed in such a manner that either his right or left wing could take the enemy in rear and reverse, so as to disable them from undertaking any thing against the part where he intended to direct his principal attack. On the other hand, Marshal Daun, perceiving that the king was serious in his design of fighting, in order to prevent confusion, sent all his baggage across the Elbe, on which he had established three bridges, in the event of a retreat being necessary. The Austrian army then changed front, and passed to the rear, its left being placed on the heights of Zinna, and its right amongst the vines in rear of Siptitz; the reserve was stationed near Groswig, the division of the grenadiers of the left wing at Weidenhain, and that of the grenadiers and carabineers of the right in rear of Neiden. Lascy retired from Schilda, on Loswig and Torgau; whilst Ried with the light troops took a position on the extreme right towards Mokrena. In this formidable position he was found, when, about two o'clock in the afternoon, the king began the attack. The latter was received by the fire of two hundred pieces of cannon, which were disposed along the Austrian front. The Prussians were thrice led to the attack; but every time they were repulsed and broken. The king at length commanded a fresh body of cavalry to advance, which at first compelled the Austrians to retire; but as fresh reinforcements continually poured in, this cavalry was in its turn obliged to fall back; and the Prussians maintained themselves with extreme difficulty, until General Zeithen, with the right wing, attacked the enemy in the rear, repulsed them, and took possession of some eminences which commanded the whole Austrian line. Encouraged by this success, the Prussian infantry once more advanced, carried several of the enemy's intrenchments, and made way for a new attack of the cavalry, which broke in with irresistible fury amongst the Austrians, and threw several bodies of them into irreparable disorder. It was now about nine o'clock, and consequently both armies were involved in darkness; yet the fire continued without intermission, and the battalions with a blind rage discharged at one another, without distinguishing friend from foe. Daun received a dangerous wound in the thigh, and was carried from the field, which probably hastened the defeat of his troops. The command then devolved on Count O'Donnell, who, finding the greater part of his troops in disorder, the night advancing, and the enemy possessed of some eminences which commanded his camp, and whence it was in vain to think of driving them, ordered a retreat, which was conducted in perfect order and dead silence; few were lost in passing the Elbe, and by far the greater part of their artillery was preserved. The loss of the Prussians was estimated at ten thousand in killed and wounded. That of the Austrians in killed and wounded is not known; but eight thousand were made prisoners, along with two hundred and sixteen officers, amongst whom were four generals.

All Saxony except Dresden recovered.

The result of the victory gained at Torgau was, that the king recovered all Saxony except Dresden; whilst General Werner having in the mean time marched into Pomerania, the Russians raised the siege of Colberg, and retired into Poland, without having effected any thing further than wasting the open country. Werner then marched to the assistance of Western Pomerania, where he defeated a body of Swedes, and at last drove them out of the country. Laudon too abruptly raised the blockade of Cosel; and afterwards, abandoning Landshut, he retired into Austrian Silesia, leaving the Prussian portion free from molestation. Daun placed one part of his army in Dresden, and the other in some strong positions which lie to the south and west of the city, by which he commanded the Elbe, and preserved his communications with Bohemia. The army of the empire retired into Franconia, and established its head-quarters at Bamberg.

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Though these successes had apparently retrieved in some measure the affairs of the king, yet his strength was in reality nearly exhausted; and in the campaign of 1761 he made no such vigorous efforts as he had formerly done. The Russians, dividing themselves into two bodies, invaded Silesia and Pomerania. In the former country they laid siege to Breslau, and in the latter to Colberg. Tottleben, who had commanded the Russian armies, was now removed on a suspicion of having corresponded with the king of Prussia, and General Romanzof appointed in his stead; a measure which, it was expected, would render the Russian operations this year more vigorous and consistent than they had ever yet been.

Schweidnitz and Colberg retaken.

The king continued strongly encamped near Schweidnitz, where he was so closely watched by Daun and Laudon that he could not attempt anything. However, he defeated the designs of the Russians against Breslau, by sending General Platen to destroy their magazines; which the latter accomplished with great success, at the same time cutting off a body of four thousand of their troops. But this only brought the more certain destruction upon Colberg, against which the body of the Russian army immediately marched, cruelly wasting the country as they advanced. The king of Prussia was unable to do any thing but send small detachments, which, although they could not oppose their enemies in the field, yet, he hoped, by cutting off their convoys, might distress them to such a degree as to oblige them to abandon the siege, or at least protract it till the severity of the winter should render it impossible for them to carry on their operations. He thus weakened his own army so much, that it was found requisite to draw out of Schweidnitz four thousand men to reinforce it; and no sooner had this been done, than Laudon suddenly attacked and took that fortress by a coup-de-main. Colberg made a brave defence; but the troops sent to its relief being totally unable to cope with the Russian army, consisting of fifty thousand men, it was, on the 3d of December, obliged to surrender; and thus the fate of the Prussian monarch, almost every part of whose dominions lay open to the invaders, seemed to be decided.

Peace between Russia, Sweden, and Prussia.

In the midst of these gloomy appearances, the empress of Russia, the king's most inveterate and inflexible enemy, died on the 2d of January 1762. She was succeeded by Peter III. who, instead of being the king's enemy, was his most sanguine friend. As early as the 23d of February, in a memorial delivered to the ministers of the allied courts, he declared that, "in order to the establishment of peace, he was ready to sacrifice all the conquests made in this war by the arms of Russia, in hopes that the allied courts will on their parts equally prefer the restoration of peace and tranquillity, to the advantages which they might expect from the continuance of the war, but which they cannot obtain but by a continuance of the effusion of human blood." This address was not much relished by the allies. They were very willing to make peace, provided it should prove for their own interest to do so; but they recommended to his attention fidelity to treaties, which constitutes no less valuable a part of the royal character than humanity and disinterestedness. This answer made no impression upon the Czar. A suspension of hostilities took place on the 16th of March, which was followed by a treaty of alliance on the 5th of May. In this treaty the Czar stipulated nothing in favour of his former confederates; on the contrary, he agreed to join his troops to those of the king of Prussia, in order to act against them. Sweden, which had for a long time acted under the direction of Russian councils, now fol-

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lowed the example of her mistress, and on the 22d of May concluded a peace with Prussia.

Successes of the king of Prussia.

It is not to be supposed that the king of Prussia would remain long inactive after such an unexpected turn of fortune in his favour. His arms were now everywhere attended with success. Prince Henry drove the imperialists from some important positions in Saxony, by which he secured all that part which the Prussians had possessed; and though the Austrians frequently attempted to recover the ground thus lost, they were constantly repulsed with great slaughter. The king was not joined by his new allies till towards the end of June; after which he drove Daun before him to the extremity of Silesia, leaving the town of Schweidnitz entirely uncovered, and which the king immediately prepared to invest. In the mean time, different detachments of Prussians, some on the side of Saxony, and others on that of Silesia, penetrated into Bohemia, laid many parts of the country under contribution, and spread universal alarm. A considerable body of Russian irregulars also made an irruption into Bohemia, where they practised on the Austrians the same cruelties which they had long been accustomed to exercise on the Prussians.

A new revolution in Russia.

But whilst the king was thus making the best use of his time, he was all at once threatened with a fatal reverse of fortune by a new revolution in Russia. The emperor was deposed, and his deposition was soon afterwards followed by his death. The empress, who succeeded him, suspected that her husband had been misled by the councils of his Prussian majesty, against whom, therefore, she entertained a mortal enmity. In the very beginning of her reign, however, she could not again undertake a war of so much importance as that which had just been concluded. She therefore declared her intention of observing the peace concluded by the late emperor; but she nevertheless resolved to recall her armies from Silesia, Prussia, and Pomerania, which indeed the unsettled state of the kingdom rendered in some degree necessary. At the same time a discovery was made regarding the king of Prussia himself, which turned the scale greatly in his favour. The Russian senate, flaming with resentment against this monarch, as well as against their late unfortunate sovereign, and the empress, full of suspicion that the conduct of the latter might have been influenced by the councils of the former, searched eagerly amongst the papers of the late emperor for an elucidation of this point. Many letters from the Prussian monarch were indeed found, but these were conceived in a strain absolutely different from what had been expected. The king had, as far as prudence would permit, kept a reserve and distance with regard to the rash advances of this unhappy ally; and, in particular, had counselled him to undertake nothing against the empress his consort. The reading of these letters is said to have produced such an effect upon the empress, that she burst into tears, and expressed her gratitude in the warmest terms towards the Prussian monarch. Still, however, the Russian army was ordered to separate from the Prussians; but all the important places which the former had taken during the war were faithfully restored.

Total defeat of Laudon.

The king, finding that the Russians were no more to take an active part in his favour, resolved to profit by their appearance in his camp; and, therefore, the day after the order for their return had arrived, he attacked the Austrian army, drove their right wing from all its positions, and entirely cut off their communication with Schweidnitz, so that nothing could be attempted for its relief. Prince Henry kept them in continual alarms for Bohemia; whilst a great share of their attention, and no small portion of their forces, were engaged on that side. Marshal Daun, now finding himself rendered almost incapable of undertaking any thing, detached Laudon, with a force greatly superior, to attack the Prince of Bevern, and drive him from the advantageous position which he occupied. But the prince defended himself with such resolution, that all the efforts of Laudon were baffled before the king could come to the aid of his lieutenant. The Austrians, being then placed between two fires, were routed and pursued with terrible slaughter; after which the king met with no further interruption in his preparation for the siege, and the trenches were opened on the 18th of July. Marshal Daun did not even attempt to relieve the place; but the garrison being very strong, it held out for nearly two months from the date of the opening of the trenches. It is said that the attack was directed, and the defence conducted, by two engineers who had written on the subject of the attack and defence of fortified places; and they were now practically engaged in proving the superiority of their systems. At last, however, the garrison, to the number of eight thousand men, surrendered prisoners of war; and the whole of this body, except nine, were soon after drowned at the mouth of the Oder, on their passage to their intended confinement in Königsberg.

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Austrians defeated at Freyberg. Peace.

The king of Prussia, having thus become master of Schweidnitz, turned his attention towards Saxony, where he reinforced his brother's army, and made preparations for laying siege to Dresden. In this country the Austrians had lately met with some success, and driven back Prince Henry as far as Freyberg; but on the 29th of October they were attacked by the Prussian army thus reinforced, and totally discomfited. After various tactical combinations, of no great importance, a simultaneous attack made by three Prussian divisions, in which they were ably supported by the cavalry, decided the fortune of the day. The loss of the imperial army amounted to four thousand prisoners, and about three thousand men *hors de combat;* that of the Prussians did not exceed fifteen hundred men of all arms, and they signalized their gallant achievement by the capture of twenty-eight pieces of cannon and nine standards. This affair does them the more honour that they had in the field only twenty-nine battalions and sixty squadrons, or scarcely eighteen thousand men, whilst the enemy had forty-nine battalions and sixty-eight squadrons, or more than twenty-six thousand men. The victory of Freyberg proved decisive. The empress-queen, finding herself deserted by all her allies, was glad to conclude a treaty, upon the principle of mutual restitution and oblivion; and thus, at the end of a bloody war, both parties were content to adopt the *status quo ante*, and sit down in the same situation in which they respectively stood before a sword had been drawn. This treaty has been called the peace of Hubertsburg.

The war was no sooner terminated than the king of Prussia turned his attention to domestic policy, and the recovery of his dominions from those innumerable calamities which had befallen them during the contest. He immediately distributed lands to his disbanded soldiers, and gave them the horses of his artillery to assist them in their cultivation. By his wise and prudent management, the horrors of war were soon forgotten; and the country ere long became as flourishing as ever. But notwithstanding this pacific disposition, the king never slackened his endeavours for the defence of his states, but kept on foot a respectable army, which might be able to act with promptitude on any emergency.

A new war commenced, but soon terminated.

In the year 1778, a new difference arose with the house of Austria, concerning the duchy of Bavaria. But though great warlike preparations were made upon both sides, and immense armies brought into the field, nothing of consequence was effected. Any little advantage obtained seems to have been on the side of the Prussians, who made themselves masters of several towns, and carried on the war in the enemy's country. However, the emperor acted with so much caution, and showed so much skill in defensive tactics, that all the manœuvres of his Prussian majesty could gain no material advantage; whilst, on the other hand,

History. Frederick was too wise to venture an engagement. A peace therefore was soon concluded; and since that time the history of Prussia, during the remainder of this great king's reign, affords no remarkable event which has not been mentioned in other parts of the present work. (See particularly the article POLAND.)

Character of Frederick. A few general remarks, however, may not be deemed altogether out of place in concluding this imperfect sketch of the military career of Frederick. He was undoubtedly a great captain, and to him belongs the high merit of having demonstrated how much success in war depends upon scientific combinations, executed with corresponding celerity and precision. But still he is not entitled to rank with the greatest masters of the art; and, compared with Napoleon, he was as much surpassed by the latter in all the higher attributes of a great commander as he excelled the captains of his own time. He was opposed to generals far inferior to those with whom Napoleon had for the most part to contend; and his tactics were frequently arranged upon the knowledge he possessed of their respective characters, rather than in conformity to the established principles of the art. Nor did he possess the invaluable secret, which Napoleon first revealed to the world in his Italian campaigns, of promptly following up his successes, and gathering in the fruits of victory, before the enemy could have time to recover from the shock of defeat. This, which is the last and highest endowment of a great general, was reserved for his immortal successor, whose campaigns afford ample and instructive examples of all that is most finished, not only in grand military combinations, but also in the still more difficult and important art of deriving from them every result which they seemed calculated to afford. Upon every occasion, however, the personal character and conduct of Frederick in the field stamped him the hero of the age in which he lived, and cannot but be viewed with admiration by every succeeding one. His presence of mind was almost supernatural; nothing could shake, nothing could for a moment disturb, the cool and steady composure with which he regarded the most frightful scenes of war. Amidst the perils of surprise at Hohenkirchen, when the fog rendered the enemy perceptible only by the murderous fire they were pouring amongst his battalions; as well as when destruction and ruin stared him in the face at Kunersdorf, where the men lay dead or dying around him in sections, and the carnage appalled even his most veteran officers; he remained as collected and steady as at a review at Potsdam, cheering and animating the troops by his voice and example, rallying them when broken or driven back, and leading them back to the charge with a standard in his hand. In a word, he was greater in defeat than in victory; and it is as much, perhaps, to his personal conduct in the field, as to his superior tactics and the natural bravery of his troops, that his principal successes are to be ascribed.

But Frederick was not continually engaged in war. He enjoyed many intervals of tranquillity, many years of profound repose. Nor did he waste these in the unworthy indulgence of luxurious ease or sensual gratification. On the contrary, every moment of his time was spent in promoting the interests and the welfare of his subjects. He occupied himself in adopting measures for promoting the advancement of agriculture and manufactures, commerce, literature, and the arts; he founded academies and seminaries of learning; he invited learned men from every country in Europe to settle in his dominions; he cleared waste lands, constructed canals, rebuilt and repaired the cities that had been dilapidated by the enemy, rewarded men of merit in every department of enterprise; in a word, he spared no labour or expense in promoting the internal improvement of his kingdom. One of his chief objects was a reform in the courts of justice, and this he effected, as far at least as regards the delay and expense of legal proceedings, the great evils that obstruct or rather defeat the administration of justice. Nor can it be doubted that the *Code Frederick*, published in 1746, and afterwards adopted throughout the Prussian dominions, if regarded as the result of one reign and the wisdom of one individual, is entitled to the hearty applause and commendation of every legal reformer. But unfortunately the soldier was uppermost in everything. The learned men whom he invited from other countries were treated by him rather as a regiment of soldiers than a body of philosophers; and even in matters of taste and literature he sought to introduce a sort of military regulation. The army was naturally enough his favourite object of attention, and in seeking to improve it he carried discipline amongst the troops to a degree of severity unknown in Europe until his time, and which subsequent experience has rendered it necessary to relax, or at least to simplify greatly in its more oppressive details. Nor, amidst all his avocations, did he lay aside his early attachment to letters and to study. To this pursuit he, in times of peace, devoted a portion of every day; and he is the author of various works which the influence of his high rank and fame was not necessary to introduce to the notice of the world.[1] The foulest stain on his memory consists in first suggesting, and then participating in, the dismemberment of Poland. Frederick planned the robbery, the Russian monarch executed it, and then the leagued plunderers divided the spoil between them.

Frederick William II. Frederick died in 1786, at the age of seventy-five, and was succeeded by his nephew Frederick William II. This prince, on his accession, found the most effectual securities for the preservation of his dominions; the finest army in the world, a people enthusiastically loyal, and a treasury replenished with seven millions sterling. Nor with these advantages was the new king wanting to himself. The predilection of Frederick for the French language and French literature was not grateful to his subjects. The new sovereign began his reign with declaring in council, "Germans we are, and Germans I mean we shall continue;" at the same time giving directions that their native language should resume its natural rank and station, from which for nearly half a century it had been degraded by the French. This was a very popular measure, and it was followed by another still more so. Observing that he had marked with great concern the progress of impiety and profaneness on the one hand, and that of blind enthusiasm on the other, he declared that he would not have his subjects corrupted either by fanatics or atheists, and strictly prohibited all publications tending to excite a contempt for or indifference about religion.

The stadtholder assisted against the states of Holland. On his accession to the throne, this pacific conduct upon the part of the new king endeared him to his subjects, and commanded the approbation of all good men. And an opportunity soon occurred in which he was thought to have displayed talents in negotiation and military arrangements, which rendered him in every respect a worthy successor of his uncle. The states of Holland, which had long been jealous of the power of the stadtholder, and inclined to a republican government without any permanent chief, had gained such an ascendency in the states-general, that in 1786 and 1787 they in effect divested the Prince of Orange of all his prerogatives. They proceeded even to the seizure and imprisonment of the princess, sister of the king of Prussia; and, depending upon support from France, they treated with

[1] The principal works of Frederick the Great are, 1. Memoirs of the House of Brandenburg; 2. Memoirs of his own Time, from the year 1740 to the Peace of Dresden; and 3. a History of the Seven Years' War. His poem on the Art of War, at first published separately, was afterwards reprinted with other poems and epistles in a volume entitled Miscellaneous Works of the Philosopher of Sans Souci.

History. insolence every power connected with them in Europe. The court of Berlin did not witness these proceedings without indignation; and the king formed a plan for restoring the power of the stadtholder, with such secrecy and prudence, that perhaps nothing could surpass it, except, indeed, the facility with which it was carried into execution. In the short space of one month, the Duke of Brunswick led eighteen thousand Prussians to Amsterdam, and restored the ancient prerogatives of the Prince of Orange.

Frederick William III. The affairs of Prussia during the early period of the French revolution, and especially the active but unsuccessful part which that monarch took against it, are interwoven with the historical details of that period given in the articles BRITAIN and FRANCE, to which the reader is therefore referred. Taking a just view of the true interests of Prussia, he availed himself of the first favourable opportunity to withdraw from the contest with republican France, in which the honour of his arms had suffered abasement; and he died in the year 1797, when his son, Frederick William III., ascended the throne of Prussia.

Perfidious policy of the Prussian cabinet. During the early part of this reign, nothing occurred deserving of commemoration. Besides the most sedulous attention to the discipline of the army, which it was his object to maintain in a state of perfect efficiency, the king occupied himself in promoting the internal improvement of his states; and in this judicious course of policy he persevered until the year 1806, when his own rapacity and perfidy involved him in a war with France, which terminated in the almost total extinction of his kingdom. Seeing the power of the French arms rapidly increasing, and admonished by the stunning blow which the Austrians had received at Austerlitz, he formed an alliance with Napoleon, and even shared in the distribution of the spoil by invading Hanover, which he annexed to his dominions, whilst he shut the northern ports of his kingdom against the British flag. The result of this base proceeding may easily be anticipated. The British minister immediately quitted Berlin, and this was soon followed by a declaration of war on the part of his Britannic majesty. His situation now became embarrassing and critical in the highest degree. Some time before the battle of Austerlitz, Napoleon had ascertained, by an intercepted correspondence, that the king of Prussia had been deeply implicated in the counsels of his enemies, and that he fully intended, in the event of the emperor sustaining a reverse in that campaign, to fall upon the rear of the French army, and complete its destruction. But the unparalleled victory of Austerlitz, which at one blow humbled Austria and staggered Russia, rendered his position one of great difficulty and danger. His treachery had been detected by a man who duly appreciated both its character and extent; and henceforward his Prussian majesty found himself treated by Napoleon as little better than a vassal prince, whose rights he disregarded, and whom he intended to punish whenever he should have accomplished the more important enterprise of thoroughly humbling Austria. The eyes of the king were further opened to the precarious nature of his situation by the confederation of the Rhine, which was now instituted, and afforded to France a secure basis of operations in any attack which Napoleon might think proper to direct against Prussia. Had the latter taken a decided part against France before the battle of Austerlitz, the independence of Europe might have been preserved. But after this auspicious moment had been allowed to pass unimproved, every chance of success was lost; and the disasters which followed were no more than might have been foreseen by any person of ordinary observation and sagacity.

In crises of imminent peril, weak minds generally choose the part which most certainly and directly leads to destruction. Early in October 1806, Prussia declared war against France, and in less than a month thereafter the monarchy had ceased to exist. Napoleon, having foreseen this step on the part of the enemy, was fully prepared to meet it. By a most rapid and skilful march on the Saale, he threw himself upon the communications of the Prussian army under the Duke of Brunswick; and this decisive movement, one of the most masterly in the whole history of war, led to the simultaneous battles of Iena and Auerstadt, in which the Prussians lost twenty thousand men, including some twenty generals, and the commander-in-chief, who was mortally wounded. This double conflict took place on the 14th of October, a memorable day in the annals of the Prussian monarchy; and with the rapidity of lightning Napoleon followed up the blow. The Prussians having lost their communications, were obliged to retire on diverging lines, which rendered mutual support impossible, and their destruction more certain. They were pursued with incredible vivacity. Erfurt, Magdeburg, and Stettin were reduced; and on the 27th of the same month, being only thirteen days after the battle, Napoleon entered the capital at the head of his victorious legions. In the mean time, the king of Prussia retired, first to Custrin, and afterwards to Königsberg. The Russians had by this time come to his aid, and on the 26th of December another dreadful battle took place at Pultusk, where the allied armies were totally defeated. The French afterwards invaded Silesia; took Stralsund, Colberg, and Dantzig; and carried with them victory and conquest in every direction. And to such a state of distress was Frederick William at length reduced, that, with all his dominions except East Prussia in the hands of the enemy, the British envoy, Lord Hutchinson, on his arrival at Memel in March 1807, found it necessary to advance eighty thousand pounds for the support of his family and domestic household;[1] and this having been intimated to the British ministers, his majesty recommended it to parliament to enable him to fulfil the agreement entered into by our ambassador.

History. Campaign of 1806. Its results.

Campaign of 1807. Peace of Tilsitt. The campaign of 1807 was in all respects glorious for the French arms. The mighty battle of Friedland proved a conquest rather than a victory. By it the Russians were completely defeated and humbled; whilst the king of Prussia, as the consummation of his misfortunes, had the mortification to find himself at the mercy of the conqueror, to be disposed of as the latter might think fit. The Russians having retired beyond the Niemen, conferences took place at Tilsitt, and were eventually followed by a treaty of peace, which left Frederick William little more than a nominal sovereignty. By this disastrous arrangement the Prussian monarch, who had formerly ceded to France the duchies of Cleves and Berg, renounced the whole of his dominions situated between the Rhine and the Elbe, part of Lusatia, the city of Dantzig, all the provinces which formerly constituted part of Poland, and further agreed to shut his ports against the trade and navigation of Great Britain; in a word, he gave up about ten thousand square miles of territory, containing a population of about five millions of souls, and had the additional humiliation of being forced to assist in carrying out the continental system of Napoleon. Nor was this the utmost extent of his abasement. He had to support the armies of France stationed in his territories, to pay immense contributions to the French emperor, and not only to promulgate, but enforce, in his provinces, every decree issued in Holland against the commerce of this country. Frederick William, thus humbled and reduced, endeavoured to submit with patience to his fate, and to alleviate the sufferings of his subjects by effecting great reductions in his civil and military establishments.

Peace. This peace, which, as Napoleon fulfilled none of his en-

[1] By this time peace had been re-established between Great Britain and Prussia.

History. gagements, could only be regarded as nominal, continued nevertheless for six years, during which time all the calamities attendant on foreign occupation by an exasperated conqueror were accumulated on this kingdom. Hence the ardour with which the Prussians ran to arms in 1813, their courage under the reverses at the outset of the campaign, and their perseverance in its prosecution. They had been excited and prepared to take arms, whenever the favourable moment for doing so should arrive, by means of secret associations formed for the purpose, and more especially by the agency of the *Tugenbund*, or Bond of Peace, whose ramifications extended to every town and village in the kingdom. Nor was Frederick, notwithstanding the thraldom under which he laboured, inattentive to the discipline and improvement of his army, in which the military spirit had nearly sunk under accumulated reverses. At one time the number of his troops was but small, scarcely exceeding 20,000 men; yet, by successive enlistments, and continually drilling levy after levy, so as not apparently to augment his force, whilst he was in reality training to arms all the youth of the kingdom, he could bring into the field, at the critical moment, more than 200,000 regularly-instructed soldiers. The French had indeed deprived the kingdom of arms, which they carried off from the arsenals; but this loss was promptly supplied by the assistance of Great Britain and other powers.

Campaigns of 1812, 1813, 1814, and 1815. Meanwhile, the disastrous termination of the Russian campaign proved the signal for the desertion of Napoleon, first by Prussia, and afterwards by Austria. It was now felt that his star had passed the culminating point, and already begun to wane. General d'Yorck took the earliest opportunity to withdraw with the Prussian contingent; a declaration of war followed; and Europe prepared to rise in arms against the military despotism of Napoleon. In the campaigns of 1813 and 1814, the Prussian army, led by Blucher, Bulow, and other able officers, distinguished itself in all the great battles, at Lutzen, Juterboch, Leipzig, in the recovery of Silesia, and also in the plains of Champagne, where, though several times defeated with great loss by the masterly combinations of Napoleon, it displayed a noble perseverance, and fought with all the spirit of a truly national army. Hostilities were for a short time suspended by the negotiations which took place at Châtillon; but Napoleon having, from confidence in his own genius, refused the terms offered, the allies decided to advance against the heart of his power, and at Montmartre, where the Prussians again distinguished themselves, the struggle ended, and was soon followed by the treaty of Paris. The abdication of Napoleon was followed by his retirement to the island of Elba, which had been assigned as the place of his exile. But early the following year he returned to France, and by a march from Fréjus to Paris expelled the Bourbons, at the same time reseating himself on the imperial throne. This extraordinary conquest, which is perhaps without a parallel in history, produced the campaign of 1815, in which the Prussians, it must be confessed, added nothing to their laurels. On the 16th of June, their army was not only defeated at Ligny, but so completely broken up, that out of more than 90,000 men of which it consisted on the morning of the battle, not 30,000 ever afterwards re-assembled. Yet this remnant having, by the united talents and energy of Blucher and Bulow, eluded the corps of Grouchy at Wavre, and appeared on the field of battle at Waterloo on the evening of the 18th, materially contributed to render the victory there achieved by the British arms decisive of the fate of Napoleon, France, and Europe.

Congress of Vienna. The immediate consequence of this mighty achievement was the settlement of the different nations of Europe according to the views of the conquerors, and in the circumstances in which they have ever since continued. The congress of Vienna had the delicate and difficult task of assigning acquisitions and boundaries to the various powers which had been engaged in the struggle; and some strange dislocations naturally resulted from this attempt to effect a general settlement at the close of a war which had been productive of so great vicissitudes of fortune. To Prussia were secured generally the restitution of the provinces formerly wrested from her, excepting part of Poland, destined to be united with the duchy of Warsaw, and ample indemnification for this partial sacrifice, in Saxony and the Lower Rhine, by the addition of such territories as were deemed consistent with the stability and security of the balance of power in Europe. The acquisitions which Prussia thus made, through the grace and favour of the congress of Vienna, were, from France, the Lower Rhine, and part of Juliers, Cleves, and Berg; from Westphalia, Munster, and the remaining part of Juliers, Cleves, and Berg; and from Saxony, Thuringia, Upper and Lower Lusatia, and Menneberg; large indemnities, it must be confessed, for parting with a portion of territory originally acquired by robbery and spoliation. In this year also, Prussia, partly by exchange, and partly by purchase, obtained from Denmark that part of Western which is commonly called Swedish Pomerania, together with the island of Rugen. And thus, after experiencing violent shocks and vicissitudes, by which the kingdom had been broken in pieces, and little more than the name of the monarchy saved from the wreck, we behold Prussia, after a series of unparalleled changes in another direction, again raised from the condition of a second-rate power, and taking her station amongst the first sovereign states of Europe, as formidable as in the days of Frederick the Great, and with a territory and population far exceeding any thing he could boast of.

Effects of the settlement of 1815. In fact, the settlement of 1815 invested Prussia with a degree of power which she had never possessed before, and we need not wonder that it should have exercised a marked influence on the general character and conduct of her government. In the agony of the struggle against Napoleon, when a sudden freak of fortune, or some bold stroke of his trancendent genius, might have disconcerted all the schemes formed for his overthrow, everything was promised to the people, and amongst the rest representative institutions. But, according to the morality of kings, "vows made in pain are violent and void," and hence impose no obligations on royal consciences. So, at least, it happened in the case of Prussia, which, so far from redeeming its pledge, has strenuously resisted every attempt made to urge its fulfilment on the government, which, if not essentially hostile to political liberty, might, from the general character of the people, have safely granted them the boon that they so much desire. But the fact that such hostility exists on the part of the government, is proved by the whole tenor and spirit of its policy, external as well as internal. To say nothing of the circumstance, that its closest political ties are with governments purely despotic, particularly with Russia, no sooner did the demand for representative institutions become general in Europe, and Spain, Naples, and Piedmont, successively extort constitutions, than his majesty Frederick William III. joined the Holy Alliance, and entered with eagerness into all the views by which that confederacy was distinguished. Having repression for its object, it was prepared to crush liberty, wherever it ventured to raise its ensign; to arrest the progress of political improvement, and to employ military force to punish all who were afflicted with any undue zeal in favour of a cause which freemen are accustomed to consider as sacred. In time, however, the Holy Alliance, with all its apparent power, yielded to the influence of events, and gradually vanished as completely as if it had never existed and domineered over the Continent. But the spirit still survives, at least in the Prussian government, which, with all its ostentatious pretensions to a species of liberality, and with the merit of having introduced some wise measures and use-

History. ful improvements, nevertheless carries despotism to a height which in this or in any other free country would be intolerable. This, we think, is very evident from the conduct which the Prussian cabinet has pursued in the formation of the German Commercial League, a measure of decided hostility against the interests of this country.

Prussian Commercial League. The extent to which this confederacy has already (1839) been carried, will astound those who have not been closely observant of the policy of Prussia during the last twenty years. The Commercial League of Germany comprises the vast territory included between the river Niemen and the Baltic at one extremity, and the Alps and the Lake of Constance at the other. On the east it is bounded by Russia, Poland, and Austria, and on the west by Belgium, Holland, and France. It consists of the union of four kingdoms, one electorate, three grand dukedoms, and more than twenty smaller states, the whole comprising 8654 German square miles, and 27,728,000 inhabitants, a population surpassing by several millions that of Great Britain and Ireland, and nearly double that of Spain. The dominions of the Commercial League comprehend the residences of twenty-six sovereign princes, several of whom, however limited in domains, exhibit a splendour approaching to that of the greatest empires. The army consists of 246,168 soldiers in time of peace, and in the event of war may be augmented to 550,000. The amount of the annual taxes paid by the population of those provinces is nearly L.17,000,000 sterling, by far the greatest part of which is derived from the custom-house duties and the excise.

Prussia created this league for the purpose of advancing her political projects, the nature of which was manifested by her sovereign as early as the Congress of Vienna. The enthusiastic efforts of the Prussian people having materially contributed to the overthrow of the common enemy, their king founded on their merit in this respect a pretension to unite under his dominion the greater part of Germany. The whole kingdom of Saxony, all the country between the Weser and the Elbe, the territory which formerly belonged to the Orange family, and that which had formed the electorate of Mayence, were all claimed by the Prussian monarch, as a reward for the sacrifices that had been made by his people. Austria resisted, however, and her resistance proved successful. Prussia was obliged to content herself with certain parcels of the principalities she coveted, and which assorted ill with the rest of her dominions. The kingdom of Prussia is, in fact, composed of incongruous and dislocated pieces. Her Saxon and Westphalian provinces are separated from each other by the territories of Hanover and Cassel, and the rest are interlaced by a number of small principalities, which offer serious obstacles to the unity and efficiency of an administrative system. Accordingly, the desire of finding an opportunity to annihilate these principalities, and unite their territories with the Prussian dominions, induced the court of Berlin to employ unscrupulous means, and resort to dangerous expedients, in order to accomplish its object.

These and other analogous intrigues, however, never interrupted the principal aim of Prussia, which seems to have been that of becoming arbiter of Germany; and it must be confessed that she has made a grand step in advance towards the attainment of that object, by imposing upon the whole German nation her commercial laws and institutions. The grand duke of Hesse-Darmstadt was the first German prince who consented to enter into a commercial league with Prussia. This was in the year 1825; and since that period Prussia has steadily pursued her great scheme of a commercial union, with a degree of success which has probably outrun her most sanguine expectations.

The acquisition of Hesse-Darmstadt served the Prussian government as a means of transit to the southern provinces of Germany. There existed already a commercial alliance between Bavaria and Wurtemberg, founded on just and equal terms, and highly advantageous to both countries. Prussia, having succeeded with the electorate, now endeavoured to prevail on both of these states to enter into the league; but for a time all her efforts were baffled by the talents of the Bavarian minister, Count Armansperg. The conferences, however, were carried on during several years; and at length, in the year 1828, a commercial contract was agreed to on both sides. This contract, however, did not stipulate the establishment of a commercial union, though it facilitated the intercourse between the southern and northern parts of Germany, by fair and moderate duties. But Prussia never for an instant lost sight of her grand object; and having effected the removal of Count Armansperg from the Bavarian ministry, her conditions were at length accepted by both states, and the southern league, consisting of Bavaria and Wurtemberg, entered into a complete commercial union with the northern league, composed of Prussia and Hesse. The contract was concluded in the beginning of 1832; and although the ruling power of Prussia was not so explicitly acknowledged in the articles of the new contract as it had been in that with Hesse, yet it was Prussia that dictated the laws of the union in all essential points, and became the arbiter in all questions of difficulty. History.

Bavaria and Wurtemberg being thus gained, it became an easy task to prevail upon the remaining principalities. The kingdom of Saxony was the only one from which resistance was anticipated. But the commercial union, being principally calculated for obtaining an open market in Southern Germany, Saxony, which abounds in manufactured products, profited by the opportunity to share in the advantages which Prussia had prepared for herself; whilst the example of the royal government was immediately followed by the smaller Saxon countries, and by all those numerous states which are neither wealthy nor extensive enough to maintain an independent commerce, and a system of internal industry. The free city of Frankfort, however, was found much less tractable. Proud of its republican constitution, and powerful by its wealth, it for a time maintained its independence; but the struggle was too unequal to continue long between a powerful confederacy and a small isolated state. By a mixture of intrigue and violence, akin to that which had been exercised against the Polish commonwealth of Cracow, the senate was at last obliged to yield, and consent to the union; at the same time declaring, that its resolution was taken, not from any conviction of its being beneficial to the republic of Frankfort, but in consequence of its federative dependence, and the greatly superior strength of its antagonist.

After the acquisition of Frankfort, the territory included in the league seemed to be sufficiently compact; but it nevertheless wanted two additional states to render it complete (*teres atque rotundus*), namely, the duchy of Baden in the south, and the territories of Hanover, Brunswick, and Oldenburg, in the north. Both were equally important for the full attainment of the objects contemplated by Prussia in securing the command of the right bank of the Rhine, and also in furthering the schemes of Russia respecting the navigation of the Baltic, and the exclusion of the British mercantile navy from that sea.

In the case of Baden, resistance, though strenuously offered, proved as unsuccessful as in that of the free town of Frankfort, and of the smaller states generally. The grand duchy was forced to enter the Prussian union; and Baden is now an integral member of the league, notwithstanding the hatred of the people against everything bearing the name of Prussia, or originating from that country. With respect to Hanover and the northern principalities of Germany, however, their position rendered it impossible for the Prussian cabinet to proceed against them in a similar way. Hanover, Brunswick, and Oldenburg were united with Hesse-

History. Cassel in a separate league, and thus remained independent of Prussian influence. Unable to surmount the difficulties opposed to her schemes by the circumstance of the connection of Hanover with England, Prussia now endeavoured to separate that kingdom from its commercial allies; and succeeded as far as concerned the electorate of Hesse-Cassel, which, openly violating the compact it had formed with its allies, withdrew from them, and joined the Prussian union. This was one point gained; whilst the accession of King Ernest to the throne of Hanover has excited hopes, we fear not altogether groundless, of drawing him into the confederacy.

At the same time it is but right to observe, that whatever may have been the original views of Prussia in the formation of the union, the immediate results deserve the acknowledgments of all Germany. Internal trade has received a new impulse; the custom-house lines, which formerly separated the German states from each other, have been abolished; and a great stimulus has been given to manufacturing industry. From Aix-la-Chapelle on the confines of the Netherlands, to Tilsitt on the borders of Russia, and from Stettin and Dantzig on the north to Switzerland and Bohemia on the south, there is nothing to interrupt the freedom of commerce: a commodity having once passed the frontier of the league, may be conveyed without hindrance throughout its whole extent. But this internal trade is governed and directed by a protector and ruler, namely, Prussia; and it has for its main object to extend throughout Germany a monopoly of Prussian manufactures, to the exclusion of all foreign competition. The same power also profits by this union for obtaining a predominant influence in the political affairs of Germany, and even endeavours to exercise this influence at the expense of the independence of the smaller German states, and of those constitutional rights which some of them have employed to the greatest advantage in improving their internal condition. Freedom in trade and commerce throughout the united German states is not alone sufficient. This is no doubt excellent in itself, inasmuch as it is regarded by the inhabitants of Germany as a patriotic institution, which strengthens the national union of their father-land, and improves the social condition of its people. But it would have been more consistent with sound commercial policy, and productive of greater advantage to the majority of the German states, if such an union had been constructed on the double basis of internal freedom, and the maintenance of an amicable intercourse with foreign countries, instead of excluding the commerce and manufactures of the latter from the German markets. As matters stand, however, the system of exclusion introduced by, and essentially connected with, the commercial league, has no other object than the establishment of a Prussian monopoly in Germany, which it consequently deprives of all the benefit that might be obtained under a more liberal and enlightened commercial policy.[1] It must, however, be admitted, that Prussia is not without good grounds of complaint against Britain, on account of her commercial policy towards the German states. Prussia has only three great staple articles of export, namely, corn, timber, and wool. In ordinary years we exclude the first of these from our markets; and on Prussian timber we levy a duty of fifty-five shillings a load, and admit American timber on payment of a duty of ten shillings; whilst the government of Prussia has always expressed its willingness to place its intercourse with foreign states on the basis of reciprocity. History.

The Rhenish provinces. The Prussian government does not appear to understand thoroughly the important maxim, *pas trop gouverner;* at least, in its conduct towards the Rhenish provinces, it has exhibited a busy, vexatious, intermeddling spirit, productive of no good whatever to itself, and the occasion of much discontent amongst the people. This tendency to interfere with details which are beyond the natural competency of any government, or which, at all events, it would be wiser to let alone, has displayed itself not only in accidental and isolated acts, but in legislative enactments and solemn transactions. The concessions which the French government had made in favour of the industry of the Rhenish provinces whilst they formed part of the French empire, were cancelled by a royal ordinance dated the 17th of September 1817; and this proceeding, avowedly intended to advance the prosperity of the eastern provinces at the expense of those on the Rhine, has since been followed by a series of others, all calculated, not only to keep alive, but to embitter the irritation which it first excited in the minds of the people. Nor has even the religion of these provinces, though ostensibly acknowledged and protected by the state, escaped the interference of the government, which, in attempting to regulate everything, has involved itself in great difficulties, and gone far to alienate the affections of the people. This is exemplified in the affair of the Archbishop of Cologne, which, after forming for several years a principal subject of its diplomacy, has at length terminated, as far as that prelate is concerned, in his forcible expulsion from his diocese, and the virtual abrogation of all ecclesiastical authority in the archiepiscopal province over which he presided.[2]

STATISTICS.

The kingdom of Prussia is situated in the northern part of Germany. It is bounded on the north by the Baltic Sea and a small portion of the duchy of Mecklenburg; on the east by Russia, and its dependent kingdom, Poland; on the south-east by Austria; on the south by the kingdom of Saxony and the Saxon duchies; on the south-west by Bavaria and part of France; and on the west by France and the kingdom of the Netherlands. In describing these boundaries, it is, however, necessary to remark, that some parts of the kingdom are small detached portions entirely insulated by the dominions of other powers, such as Neufchatel in Switzerland, Suhl in Saxony, and Rahnis in Saxe-Weimar. The whole boundary by land is in length 735 Prussian miles, equal to 3439 English miles. There is no communication between the eastern and western provinces of Prussia without passing through the dominions of other princes. Hanover, on the north, is interposed between its eastern and western provinces; and in the southern parts of it the territories of the sovereigns of Brunswick, Waldeck, Hesse-Cassel, Hesse-Darmstadt, Nassau, Saxe-Weimar, and Saxe-Gotha, intercept the direct communication.

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[1] See an article on this subject in the Foreign Quarterly Review, No. xliv. p. 306, *et seq.*

[2] We had intended to give a pretty full narrative of this extraordinary occurrence; but considering that, in one sense at least, the affair is not ended, the Prussian government having again opened negotiations with the Court of Rome, we deem it the wisest course to abstain altogether from attempting to give an exposition of a transaction which is still incomplete. It is sufficient to say, that the Prussian government seems to feel its situation to be anything but a comfortable one; and, if a judgment may be formed from the notes addressed to the Cardinal Secretary, Lambruschini, by its envoy, Bunsen, since the expulsion of Baron Droste from the archiepiscopal see of Cologne by military force, it would gladly retrace its steps, and fall back from the aggressive position it has assumed, if it could do so without humiliation and disgrace. By the last accounts, however, the sovereign pontiff, Gregory XVI., had refused to listen to any compromise. "Restore the archbishop to liberty, replace him in the full exercise of his ecclesiastical functions, and then I will hear you," said Gregory, "but not till then."

Statistics. The great division of Prussia is into those provinces which are in Germany, and form a part of the Germanic confederation, and into those states which have no connection with that alliance. Statistics.

	Extent in British Statute Acres.	Population in 1834.	Children at School.	Proportion of Children at School to the Population.	Capitals.
German Provinces.				One out of	
Brandenburg	11,025,280	1,651,320	280,658	5·88	Berlin.
Pomerania	8,331,520	941,193	150,404	6·26	Stettin.
Silesia	10,598,400	2,547,579	446,061	5·71	Breslau.
Saxony	6,663,040	1,490,583	291,811	5·11	Magdeburg.
Westphalia	5,534,720	1,292,566	225,954	5·72	Munster.
Provinces of the Rhine	6,365,120	2,392,743	370,764	6·45	Coblentz.
Russian Provinces out of Germany.					
East and West Prussia	17,178,240	2,073,378	336,757	6·16	Dantzig.
Posen	7,919,360	1,120,668	132,950	8·43	Posen.
	73,615,680	13,510,030	2,235,359	6·04	

Of the children at school, 1,159,434 were males, and 1,075,925 females.

The duchy of Neufchatel is not included in the above statement, because its situation and constitutional laws differ materially from the rest of the Prussian dominions. In 1831 it contained a population of 54,080. In the same year there was an average population per square mile,

In the province of Prussia, of.....1689 inhabitants.
Posen, of.....1951 ...
Brandenburg, of....2103 ...
Pomerania, of.....1567 ...
Silesia, of.....3269 ...
Saxony, of.....3100 ...
Westphalia, of.....3380 ...
Provinces of the Rhine.....4633 ...

Consequently in the whole kingdom there were on an average 2576 inhabitants to every square mile.

The population has increased very rapidly within the last twenty years. In 1819 there were, in 937 towns, 2,730,487 inhabitants. In 1831 the same towns contained 3,229,473, the increase being more than 18 per cent. The increase in the towns in the province of Brandenburg was about 23 per cent., in the province of Pomerania nearly 22 per cent., whilst in the province of Prussia it was only about 13 per cent. The population of the whole kingdom from the year 1819 to the year 1831 increased from 11,084,993 to 13,510,030, or about 21¾ths per cent.

In 1829 there were in the whole kingdom, of marriages, 108,881; of births, 495,382; and of deaths, 388,255. During the fifteen years from 1820 to 1834 inclusively, there was an yearly average of births, males 260,436, females 245,765; of deaths, males 187,650, females 176,164.

The inhabitants of Prussia are of different races. The most numerous body are of German origin, divided by language and customs into the High and Low Germans. These, except in the province of Posen, form everywhere the great majority. The Low German or *Platt Deutsche* language is generally spoken in the countries between the Rhine and the Elbe, on the north side of the Hartz Mountains, and prevails along the Baltic through part of Bandenburg and Pomerania. In Silesia, in the southern part of Saxony, in the trans-Rhenish provinces, and in East Prussia, dialects, or rather differing idioms, of the High German, are spoken, but all far removed from the pure language of Saxony, or, as it is called, *Der Meissnichen Dialect.* The Walloons, in the vicinity of the Forest of Ardennes, and the colonists descended from French refugees at the time of the revocation of the edict of Nantes, are now much mixed with the German inhabitants; but many of them have confused the two languages, and speak a kind of German-French *patois.* Amongst the higher classes in every part of the kingdom the pure High German language is spoken, generally with the peculiar idiom and pronunciation of Berlin; and that language is universally used in books, in the churches, in the courts of law, and in the more important transactions of commerce.

There are about 10,400,000 Germans, Sclavonians, Poles, Lithuanians, &c. Those of Sclavonian origin amount to nearly two millions, and retain their original language. The greater part of these are usually denominated Poles, and are the inhabitants of parts of Posen, West Prussia, and Silesia. About 50,000 people in Lithuania have a peculiar language of their own. The *Wenden* or Vandals have also a different language from all the other subjects of Prussia. They are between two and three hundred thousand in number, and are settled, a few in the province of Brandenburg, and the remainder in the province of Pomerania, and the districts of Leignitz and Kassubon in East Prussia. The Jews, according to the census of 1828, amounted to nearly 170,000 individuals; they are to be met with in every part of the Prussian territory, but principally in the province of Posen.

The established religion of Prussia is the Protestant, now denominated the Evangelical Confession, comprehending Lutherans, Calvinists, Hernhutters or Moravians, and Hussites. The professors of it amounted in 1828 to 7,738,664 individuals. They were formerly divided into two sects, the Lutheran and Reformed, but are now united into one, and form a large majority in the circles of Königsberg, Gumbinnen, Dantzig, Berlin, Potsdam, Frankfort, Stettin, Koslin, Stralsund, Breslau, Reichenbach, Leignitz, Magdeburg, Merseburg, Erfurt, and Minden. At the same period the Roman Catholics amounted to 4,816,813, and formed the majority in the districts of Marienwarden, Bromberg, Posen, Oppeln, Munster, Arensberg, Cologne, Dusseldorf, Cleves, Coblentz, Nachen, and Treves. The United Brethren, or Hernhutters, may be reckoned at between 10,000 and 12,000 souls. The Mennonites, a species of Anabaptists, amounted to 15,655; and the Jews, as before stated, to about 170,000. The proportion of each religious denomination was in 1825 calculated in the following manner: Supposing the whole population of the Prussian kingdom to be unity, the various religious divisions are, Evangelical Christians, 0·6067; Roman Catholics, 0·3795; Mennonites, 0·0013; Jews, 0·0125; or, in other words, in every 10,000 inhabitants there are 6067 Protestants, 3795 Ro-

Statistics. manists, 13 Mennonites, 125 Jews. These different sects are all equal in the eye of the law, have the same protection for their worship, and are all alike eligible to every civil, judicial, and military office.[1]

The different classes of inhabitants in Prussia may be divided into nobles, landed proprietors, burgesses, with more or less extensive privileges, and peasants. At the head of these the nobles are of two kinds practically, though not legally. The high nobility are the princes, who were formerly petty sovereigns on their own estates, but whose independence has merged in the general government; they amount to about fifty families. The lower nobility, consisting of about two hundred thousand individuals, have preferable claims to certain offices in the army, the state, and the church; but their privileges have been gradually contracting, and they are now in almost every point only equal to the burghers or citizens. Some of the Prussian nobles are the descendants of the Teutonic knights, who renounced their monastic vows; but other noble families came at a later period from the north of Germany. The Prussian aristocracy is not a wealthy order; their estates are of little value; it is supposed that the greatest income derived from the land of any one noble does not exceed L.2500. The higher ranks of nobility, the princes, dukes, counts, earls, viscounts, and some of the ancient barons, are not subjected to military duty by conscription, and pay no personal taxes. The higher clergy, namely, the bishops, abbots, provosts, &c. have all these prerogatives, and the same rank as the nobility. The burgesses are a numerous and respectable class of inhabitants, but they differ according to their origin and the size of their towns; the descendants of the German colonists being more enlightened than those sprung from the Poles and the Wendes. Traces of the ancient freedom enjoyed by the Hanseatic towns may still be observed in Memel, Königsberg, Elbing, Dantzig, and Thorn. The burgesses of Dantzig are peculiarly distinguished for their general intelligence, and their active and industrious habits. The power of the guilds in the cities has been gradually diminished, and they are now scarcely obstacles, as they were formerly here, and still are in other parts of Germany, to the exercise of industry and ingenuity in any profession which individuals may select for themselves. The largest class is composed of the *baueren* or peasants. They were formerly slaves, and were usually sold, as in Russia, with the estates to which they were attached; but their lot has been progressively ameliorated, and during the reign of the present king the last vestiges of this barbarism have been totally abolished. The final extinction of personal slavery was not decreed till September 1811; and, from the military events which speedily succeeded, it was not practically destroyed till several years afterwards. At present the peasantry, who amount to two thirds of the whole population, are a species of copyholders, with customary quitrents and herriots to the landowners; but they may purchase land and become themselves proprietors, a benefit only recently conferred upon them, and which those who are industrious and economical very eagerly avail themselves of. The condition of the peasantry varies considerably throughout the different provinces of which the Prussian monarchy is composed. In some they are slothful, ignorant, and superstitious, whilst in others the efforts of the Prussian administration to improve their moral and intellectual condition have been attended with success. The peasants on the werders, and the inhabitants of the new colonies, are the wealthiest and most intelligent of the peasantry. Their houses are not destitute of elegance, and their children are well educated. The other extremity of the country is inhabited by Lithuanian peasants, the descendants of the ancient Pruczi; they retain their native dialect, and are still ignorant and slothful. The coarse cloth with which they are clad is manufactured by themselves; and all of them wear a sort of scarf, or, as it is called, a *margin*, which appears to be the same as the plaid of the Scottish Highlanders. The boots and the hats of the women are nowise different from those of the men. "The German millers form almost a distinct caste; the happy inhabitants of a romantic country, possessing numerous flocks, abundantly provided with fish, poultry, and game, they make up the class between the peasantry and the nobles, and neither associate with the one nor the other, all of them intermarrying amongst themselves." (Malte-Brun.) Statistics.

In so extensive a territory as Prussia, there will necessarily be great inequalities in soil, productions, and climate. The greater part of the country is a sandy soil, generally very level, and often covered with heaths. The woods of it are nearly one fourth of the whole surface, and only certain portions near the rivers, or in particular situations, can be considered as fertile, or even grateful soils. Many barren sandy plains are to be found, which are deemed to be more expensive to bring into cultivation than could be repaid by their productions. This is especially the case in the Churmark, in Lower Lusatia, and in some of the Westphalian provinces, where large spaces are occupied by heaths, such as the heaths of Minden, which extend over ten thousand acres, those of Lippstadt, of twenty thousand, and the still larger ones of Senner and Fuhling. In East Prussia there are several very extensive morasses, which require draining to render them productive. In the fruitful district of Magdeburg, the bog of the Dromling covers more than a hundred thousand acres. A part of it indeed is in the Hanoverian and a part of it in the Brunswick territory, which prevents the necessary drains from being executed, which would make it one of the most valuable tracts of land in that part of Germany. Soil and climate.

The most fruitful corn-land in the kingdom of Prussia is the vicinity of Tilsitt, and some other districts of East Prussia, and the greater part of the duchy of Posen. That province forms physically a part of Poland; the same plains, the same kind of sand intermixed with clay and black loam, the same fertility in corn, and the same sort of forests, may be observed in the two countries. But many large marshes covered with weeds and brushwood are still undrained in

[1] According to an act passed in 1817, the Protestant clergy in each province are regulated by a synod composed of all the superintendents, headed by a president. They meet once or twice a year in a General Assembly, and consult on the internal affairs of the churches belonging to the province. They also superintend all schools, and take especial cognizance of the religious instruction given in them. Their decisions are sent to the minister of the interior, furnished with the approval of the consistory of the province. The Roman Catholics are divided into two archbishoprics, the one of which comprehends the eastern, the other the western provinces, nine dioceses, and about 3200 parishes. Gnesen is the metropolitan see of the eastern, Cologne that of the western districts. No archbishop or bishop can be elected without the sanction of the king. The annual stipend of the archbishops is about L.1720 sterling, that of the bishops about L.1150 sterling, besides perquisites. Public pilgrimages out of the country are entirely prohibited, and none allowed within the state which extend to more than one day's journey. It is worthy of notice, that in Silesia the number of Roman Catholics has diminished, and still continues to diminish. Like the Society of Friends, the Mennonites are opposed to the use of offensive arms. They are, therefore, by the act of 1815, exempted from military service; but, to counterbalance this privilege, they are obliged to contribute a sum amounting to about L.720 a year towards the support of the military academy at Culm. The Jews are acknowledged as Prussian subjects, and enjoy the same rights and privileges with the Christians. They can fill any post or office, and can hold real estates of all kinds, and follow all lawful callings. They are of course obliged in return to contribute to the support of the state, and are subjected to military service by conscription. They are, however, not admitted as teachers in the public academies and universities, owing to some impediments which arise in the discharge of these functions. Apostacy from Christianity to Judaism is not tolerated.

Statistics. the province, particularly along the winding course of the Obra. In West Prussia, the district of the Netz, the country around Marienburg, and that near Dantzig and Elbing, are excellent corn countries. That part of Silesia which is on the east of the Oder forms a very large plain, slightly undulated by hills, and differs in no respect from the plains in Poland. But in the western districts the land is more unequal, and that portion of Silesia is bounded by high mountainous chains. This province also contains several large and humid meadows and marshes. The land in Brandenburg is low, and in general sandy. Its inclination is so inconsiderable, that a great many marshes and small lakes are formed by the inundations of rivers. In this province only some districts, such as the mark of Prignitz, and the Ukermark, are celebrated for the quantity and quality of their grain; but the country abounds in forests of fir, pine, oak, beech, and ash. In Pomerania the soil is almost entirely formed by accessions from the sea, and alluvial deposits from rivers and streams. A great part of the country is covered with forests and extensive heaths, and it is only the banks of the rivers and of the lakes that can be advantageously cultivated. The soil is very favourable for all kinds of grain in the duchies of Saxony and Magdeburg, in Thuringia, and in the principalities of Halberstadt and Quedlinburg. These divisions, in favourable seasons, may be considered as the real granaries from which the less fertile parts of Prussia draw their supplies of corn.

The western parts of the Prussian dominions are far less productive than the eastern. A few only of the Westphalian provinces are highly fruitful. The districts most eminent for fertility are the vicinity of Minden and of Paderborn, the borders of the Soester, and the circles of the Lieg and the Wupper. In the Rhenish provinces, the neighbourhood of Juliers, Bonn, Cologne, Coblentz, Kreusnach, Bacharach, and the banks of the Meuse, are tolerably fertile. The principality of Neufchatel is very mountainous. Six or seven valleys, some of which, such as those of Rutz and Travers, afford rich pasture, make up the greater part of the land.

The climate varies considerably in the different districts. It may generally be described as temperate and healthy, though, from the great variety of situations, there are many exceptions. On the borders of the Baltic the winters are severely cold, and the weather changeable, raw, and foggy. The greatest degree of cold in the last century was from the 21st to the 25th January 1795, when Reaumur's thermometer was at 24° below zero. The greatest heat of that century was in the following summer, when the same thermometer was at 36° above zero. The middle provinces of Posen, Brandenburg, Silesia, Saxony, and the whole western parts of the monarchy, possess a more mild and less variable climate, but very different in the several localities. The atmosphere of Brandenburg, though mild, is humid, and subject to frequent variations in temperature; and is, besides, often exposed to violent storms from the south and the east. On the sandy plains of that province the heat is in the summer very oppressive, and the air, from the abundance of stagnant water, frequently unhealthy, whilst in the vicinity of the Hartz the cool mountain breezes are enjoyed. Silesia suffers great disadvantages from snowy winters and rainy autumns. The air is in many parts salubrious, but the southern districts, from the thick forests, and the elevation of the soil, are exposed to long and severe winters. The climate is milder in the northern part of the country; but the lakes and marshes infect the air in several places, and render it unwholesome. The banks of the Rhine and Moselle are covered with verdure before the inhabitants of Riesengebirge, and of the Lithuanian heaths, have laid aside the fur pelisses of the winter.

Rivers. Few of the countries of Europe have been more favoured by nature than Prussia with streams that contribute to fertility and intercourse; and the labour of the inhabitants has been advantageously directed to several public works, which have facilitated the communication between the different rivers. As the slope of the whole Prussian dominions is towards the west and north, all the rivers that rise in or pass through them empty themselves either into the Baltic Sea or the German Ocean. The streams that merge in the first of these are the Niemen, which rises in Lithuania, and becomes navigable at Schmaleninken; about ten miles below Tilsitt it divides into two branches, which, through the maritime lake of Curisch-Haf, empty themselves into the sea. The German name of the Niemen is derived from the town of Memel, which is built at the outlet of the same lake. During its short course through the Prussian territory, the Niemen receives on its right side the waters of the Schesschappe, and on its left those of the navigable river Jura. The river of the hills, the ancient Prussian Prigolla, the modern Pregel, is composed of the united streams of the Pisa, Ranet, Russe, Augerap, and Inster; after it assumes its name it receives the Deinenear, Tappiau, and the Alle near Wehlau. It becomes navigable near Gottenburg, and, passing Königsberg, discharges its streams by the Frisch-Haf into the Baltic. The Vistula, the Polish Wisla, or the German Weichsel, rises in the Austrian part of Silesia. It passes through Poland, where at Cracow it becomes navigable. On its entrance into the Russian territories it divides into two branches, the eastern of which takes the name of the Nogat, and joins the Baltic near Elbing; the western is again subdivided into two arms, one of which is lost in the Frisch-Haf, and the other reaches the sea near Dantzig. Its course after entering Prussia is about 140 miles, and during its progress it is augmented by the streams of the Ossa, the Brahe, and the Mottlau. Geographers have been led to suppose, and not without probability, that the Vistula is not so deep as it once was; it is certain that it may be forded in the vicinity of Thorn. The Oder, which in the German dialect of Pomerania is called the *Ader*, and of which the ancient Wendo-Slavonic name is the Wiadro, a word that signifies a *pitcher*, has its source in the mountains of Moravia, in the ancient circle of Olmutz; but the Elsa, which rises from the base of the Carpathians, is in reality the principal source. It becomes navigable near Ratibor soon after entering the province of Silesia, and, after passing through Brandenburg and Pomerania, divides into two branches, and enters the great estuaries which communicate with the Baltic Sea through the three mouths of Peene, Swine, and Divenou. Its course in the Prussian states is 370 miles; the general rate of its current is languid, forming in many places large fens and turbid lakes; and it is prevented from overflowing by embankments. It receives near Oderberg the waters of the Oppa, near Breslau those of the Ohlau, near Grosglogau those of the Bartsch, near Neuzelle those of the Neisse, and at Custrin those of the Wartha. This last is the most valuable of all the secondary rivers of Prussia, because it affords the means of a communication between the Oder and the Vistula. The rivers of Prussia which empty themselves into the German Ocean are, the Elbe, which rises in the Riesengebirge, or Giant's Mountains, and is known at its source by the Slavonic name of the *Labbe*. It receives from the south of Bohemia the Moldawa or the Bohemian Oritza, which, as it is deeper and broader than the Elbe, ought perhaps to be considered as the principal river. It is navigable at Muhlberg, where it enters Bohemia. It receives the Elster near Wittenberg, the Muldau near Dessau, the Saale near Saalhorn, and the Havel near Werben; soon after which, in its passage to the ocean, it quits the Prussian dominions. The Weser enters but a small portion of the territory of the Prussian kingdom, though it forms the boundary on the eastern side of the Westphalian provinces, from Holtzminden to Carlshafen. The only part where both its banks

Statistics. are in Prussia is near Minden, where it has forced its way through the range of mountains, and formed the celebrated passage well known to the ancients as the Porta Westphalica. The Rhine enters the lately acquired provinces of Prussia at Bingen, a little below Mentz, and quits them at Kerkerdom, above Nimeguen. From Bingen to the country above Coblentz it is confined by mountains, and small islands and headlands are formed by the rocks. It receives within the Prussian territories the streams of the Nahe; the Lahn, that is concealed under mountains; the Moselle, which, free from shallows and every incumbrance, resembles in its meandering course a canal fashioned by the hand of man; the Ahr, the Erft, the Ruhr, and the Lippe. The Ems, though it rises in the province of Westphalia, is a small stream, not navigable till it enters the kingdom of Hanover.

Canals. Most of the rivers of Prussia are so advantageously connected with each other by means of navigable canals, that an uninterrupted communication is maintained by them from Halle and Magdeburg to Elbing, and the surrounding districts have the benefit of those facilities for exchanging their various productions. The Fredericksgraben Canal, in East Prussia, is formed to avoid the dangerous navigation of the Curisch-Haf, in the intercourse between Tilsitt and Memel. The Bromberg Canal joins the Netze and the Brahe, and by their means the Oder and the Vistula. It is the most expensive of all the Prussian canals, having within eighteen miles ten locks. The commerce on it furnishes freight to about 600 barges annually, each of thirty tons burden, besides smaller boats. The Finnow Canal, which unites the Oder and the Havel, is about twenty miles long, and has on it about 4000 small, and from 1600 to 1700 large boats. The new Oder Canal shortens the navigation of that river, and serves also for the purpose of draining the meadows through which it passes. The Plauen Canal connects the Havel with the Elbe, and is the channel of intercourse between Berlin and Hamburg. The Friedrich-Wilhelm, or Mullros Canal, unites the Oder and the Spree. Besides these, there are others of less importance, as the Storkow, the Werbellin, the Klodnitz, the Saxon, and the Munster Canals, all of which are of local benefit; and the Rhine Canal, begun in 1809.

Lakes. The lakes of Prussia, especially in the eastern portions of the kingdom, are numerous and extensive. On the coast of the Baltic the two fresh-water lakes, denominated the Curisch-Haf and Frisch-Haf, may be considered as the most remarkable phenomena in the physical geography of Prussia. The former, which received its name from the ancient Cures or Coures, who inhabited its banks, is sixty-six miles in length, and varies from fifteen to thirty in breadth. It is divided from the sea by a narrow stripe of land. The sand-banks and shallows on this lake are so numerous that it is only navigable for boats, and they, too, are exposed to frequent hurricanes. The Frisch-Haf, or fresh-water lake, is about sixty miles in length, and from six to fifteen miles in breadth. It is separated by a chain of sand-banks from the Baltic Sea, with which it communicates by a strait called the Gatt. The Stettin-Haf is of nearly the same extent. Besides the lakes on the shore, those in the interior of the country are stated to exceed 1000, many of them from ten to twenty miles in length. In East Prussia are 300, in West Prussia 160, and in the province of Brandenburg 680. Many parts of these lakes have been contracted by embankments, and the soil which they covered gradually appropriated to agricultural purposes. At present they supply vast quantities of fish, the right to take which is in many instances farmed at very high rates.

Agriculture. The cultivation of the soil is the employment of three fourths of the inhabitants of the Prussian dominions. The wants and the industry of the inhabitants, aided by a rigid parsimony, directed and stimulated by a paternal though absolute government, have changed, in the course of the last century, the most sterile and unproductive kingdom of Europe into a territory which more than supplies the demands of its own inhabitants, and leaves a surplus quantity of corn in most years for exportation to other countries. In the three provinces which communicate with the Baltic Sea, viz. East Prussia, West Prussia, and Pomerania, it is calculated that four fifths of the inhabitants subsist wholly by producing food. In these provinces, in the sense of the term as it is used in our country, *farmer* is still almost unknown. Almost every proprietor, whether a large or a small one, cultivates his own land; and all the operations of agriculture are performed in a slovenly and indolent manner. The general course of cultivation is to fallow every third year, by ploughing three times if intended for rye, and five times if for wheat, the land being allowed to rest the whole of the year from one autumn to another. The extent of land sown with wheat does not amount to one tenth of that on which rye is grown. After the wheat or rye is harvested, oats or barley are sown in the succeeding spring. This rotation completes the course, which is again succeeded by a whole year's fallow, so that the land only bears corn two years out of every three, and the soil is so poor that the last crop is considered as a good one if it yields three times the seed. The implements of husbandry correspond with the state of agriculture and the nature of the soil. They are almost wholly formed of wood, and are constructed in a very rude and clumsy manner.

In the province of Brandenburg the soil is unproductive, but the husbandmen are industrious; and since the encouragement given to agriculture by Frederick the Great, uncultivated lands have been covered with harvests, thick forests have been changed into rich meadows, many unwholesome marshes have been drained, and, in consequence, the land throughout the province has risen in value. The crops in Silesia are inadequate for the numerous population, and a quantity of grain is imported into the province from Poland and Austria.

The principal grains of Prussia are wheat, rye, barley, and oats. The quantity of rye far exceeds that of every other kind of corn; it forms the principal aliment of the inhabitants, amongst whom wheat is seldom eaten in bread. Pease, both white and gray, are extensively raised, and especially that description of them known in England by the name of "Prussian blues." Beans of all varieties are cultivated in the soils on the borders of the rivers, which are suitable to their growth. Buckwheat is much sown in some places, and forms an important part of the sustenance of the labouring classes. An article for food is collected in Prussia, especially in Brandenburg, from the seeds of the grass called *festuca fluitans*. It is manufactured into a substance called *manna grits*, and is far more agreeable to the taste, though employed for the same purposes, than oat-meal with us. The cultivation of potatoes has for many years past been gradually extending, and is become so great as to supply almost the sole aliment of a very great proportion of the labouring population.

Table of the Average Prices of the four principal sorts of Grain in the different Provinces of Prussia in the year 1836.

	Wheat.		Rye.		Barley.		Oats.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Rhenish Provinces	26	8	20	2	16	7	11	8
Westphalia	24	9	19	1	15	8	10	11
Prussian Saxony	23	6	17	4	14	6	11	0
Brandenburg and Pomerania	23	0	16	1	13	1	10	3
Silesia	21	0	12	0	10	5	7	5
Posen	21	1	12	2	11	2	8	5
East and West Prussia	20	11	12	6	10	3	7	1
The whole kingdom	23	0	15	7	13	1	9	6

Statistics. The most productive branch of rural economy next to corn is that of breeding and fattening cattle. The practices in this branch are, however, of a very imperfect kind; and though the different races, especially of cows, are to be found in Prussia, yet so little attention has been paid, by crossing them, to obtain the most perfect animals, that they are almost all very indifferent. The proportion which the number of cattle of every description bears to the land is much too small. It appears, from an official account published in 1819, that the stock of cattle in the maritime provinces of Prussia at the end of that year was as follows:—asses and colts, 556,839; oxen, cows, and calves, 1,171,434; sheep and lambs, 2,049,801; swine, 617,310.

According to the lowest estimate relative to the stock of cattle in England, there are more than three times the number of horses, and upwards of four times the number of oxen and sheep, in the same extent of land. The sheep generally are bad, but of late years very great improvements have been made in their fleeces by the introduction of the Merino and Paduan rams. It is supposed that the sheep increased in the Prussian provinces between the years 1819 and 1824 at the rate of twenty-five per cent. and that the finer sort of sheep have increased in a still greater ratio. The fine-woolled sheep are now pretty numerous, and supply the manufacturers with that raw material, which used formerly to be furnished principally from Spain.[1] The monied value of the live stock on the farms is very low. The best flocks of Merino sheep, exclusive of the wool, do not bring more than six shillings or six shillings and eightpence a head. Cows are worth from thirty to sixty-five shillings, and the variation in their price is much greater than in that of sheep. The races of horses are not good, though great efforts have been made by the government to improve them; and establishments of stallions, for gratuitous propagation, are fixed in several parts of the kingdom. The breeding of swine is a very considerable employment, and the hams, bacon, and sausages made from them form a large proportion of the animal food of the inhabitants of the Prussian dominions.

The great deficiency in the rural economy of Prussia, as in most parts of the Continent, is the small portion of land appropriated to pasture. Hence the number of cattle maintained is small in proportion to its extent; and the effect of the deficiency of manure is to be found in the small increase upon the different crops of grain. The average increase is stated to be six for one of wheat, five and three quarters for one of barley, four for one of rye, and four and a half for one of oats. The land of the kingdom is thus appropriated.

	English Acres.
Under the plough	29,224,741
In garden culture	295,302
Vineyards	36,908
Meadows and pasture	14,672,000
Woods, forests, and plantations	17,574,294
	61,803,245

The remaining 11,800,000 acres are either in lakes, ponds, rivers, canals, roads, the sites of cities, towns, and villages, or of so bad a soil as not to be deemed worth cultivation.

Besides articles for food, the soil of Prussia produces many for commerce. The principal of these is flax, which is grown in every village, and almost by every peasant. Besides what is used by the growers for their own domestic manufactures, the quantity annually brought to market is very considerable. Two thirds of this quantity is produced from Silesia alone. It is generally of a good quality, with a fine and long fibre, especially when raised from foreign seed. This change of seed is found so essential, that large quantities are annually imported from Livonia and other Russian provinces; and the seed preserved at home is mostly used for making oil and oil-cake, with the latter of which the oxen are fattened. Thread is also made from felwort, a plant of which the cultivation is rapidly increasing. Tobacco, madder, woad, saflour, and hops, have been much grown, especially during the continental restrictions of Napoleon; and though the opening of foreign commerce has greatly discouraged their cultivation, they are still continued upon a small scale. Chicorium or succory, as in other parts of Germany, is much used as a substitute for coffee; and though the peace has reduced the price of the latter article, the succory finds an extensive sale, and is still cultivated very largely in many districts. It was in Prussia that the experiments of Margrave concerning the extraction of sugar from beetrave were first put into practice upon a great scale; and works were erected long before the process was generally known in France. And although commercial transactions are now facilitated by the communications that have been opened during peace, the making of sugar from beetrave has become an important branch of industry in Prussia. The wine made in Prussia before the acquisition of the Rhenish provinces was of a bad quality, and scarcely superior to vinegar; but these territories yield wine of good flavour and great strength. The annual quantity is calculated to vary from six to eight millions of gallons. Prussia, like the rest of Germany, is well provided with alimentary vegetables of excellent quality. The culture of cabbages, and the different sorts of turnips, carrots, pease, and beans, has been carried to a great degree of perfection. The silk raised in Silesia and some other districts is too inconsiderable to be of much value; but the bombex or silk-worm succeeds well in the province of Brandenburg, and the quantity of silk derived from it is very considerable. The forests, amounting to nearly two sevenths of the whole country, furnish large quantities of timber for building and for exportation; fuel, tar, pitch, rosin, and potash, are more valuable, from the great facilities which the rivers and canals afford to internal navigation, by which their products can be easily conveyed to the borders of the sea. Game is rare or abundant, according as the districts are well or ill wooded. The bear and the elk, the wild boar and the stag, are frequently seen in the woods and the forests of Prussia proper; but the elks and the wild oxen are very rare in the other provinces. The lynx is sometimes seen on the mountains, where are also met the wild cat and the badger. The wolf is now rare; and the fox, the marten, and the beaver, are not nearly so common as they formerly were. The fish that abound in the rivers afford the means of subsistence to many of the inhabitants. Some of them are of an excellent quality, and there are several kinds in the Spree that are so much prized as to form a lucrative branch of exportation. The salmon abounds most in the Rhine; but it is by no means rare in the Elbe and the Weser. The sturgeon, of which the length is sometimes from twelve to fourteen feet, the sparus, the glanis, that weighs from forty to fifty pounds, are often taken in the Oder, and the finest trouts in the rivers that flow from the Hartz and the Erzgebirge. The lamprey and the loach are not uncommon; and numerous marshes or lakes abound with pike, murenæ, and trouts.

Minerals. The mines of Prussia are by no means worked to the extent of which they are capable. Every province possesses

[1] In Silesia the flocks are shorn twice a year, and the summer's wool is considered as the most valuable. The number of sheep throughout that province is upwards of two millions three hundred thousand, and their annual produce varies from three millions five hundred thousand to four millions of pounds.

Statistics. iron, which is prepared in forges and blast-furnaces in their vicinity. They are principally worked with charcoal from the neighbouring forests; but in some instances with fossil coal. Little or no iron is exported, as it can be made cheaper in countries which have more easy access to the ocean. The mines of rock-salt, and the salt springs, are sufficiently worked to supply the consumption of their vicinity; but the provinces in the Baltic Sea find it more advantageous to draw their supply from the mines of Cheshire. Coals are found in Silesia and Saxony, Westphalia and Brandenburg; but the mines are not extensively worked. From the unproductive state of the gold-mines in Silesia, they were abandoned in 1798. The silver-mines are those of Tarnowitz and Rudelstadt in Silesia, and of Mansfeld and Rothenburg in Saxony. In Tarnowitz there is an extensive and valuable lead-mine, in which the silver is found. It is supposed that in ancient times the mine yielded about fifteen or sixteen thousand quintals of lead, and between three and four thousand marks of silver; and it has been affirmed that the annual produce of the mine is at present greater. In Silesia there are found also slate, mill-stones, marble, serpentine, porphyry, rock-crystal, jaspers, carnelians, onyxes, agates, and a particular sort of chrysoprasus. The other minerals of Prussia are copper, cobalt, calamine, arsenic, alum, vitriol, and saltpetre; but they do not yield sufficient for the internal consumption. Amber is almost an exclusive production of Prussia. It is found in mines, as well as procured by the fishermen on the shores of the Baltic. Its value is at present much less than it was in ancient times; but in some manufactories in Prussia workmen are still employed in making from it small jewels, scented powder, spirituous acid, and a fine oil that is used as a varnish. Part of the raw material is exported by the Danes and Italians; but Turkey is the staple market for the commodity. The quantity which is found in Prussia amounts annually to more than two hundred tons, and the revenue which the crown derives from it is equal to three or four thousand pounds.

Manufactures. Prussia is a manufacturing country, though these branches of industry give employment to a far less portion of its inhabitants than the cultivation of the soil. The most natural and important manufacture is that of linen cloth, the raw material of which, and all the articles that contribute to its perfecting, are produced at home. It has long been established, and extensively spread. In Silesia especially, the habit of spinning fine thread has given to the females a delicacy of tact that is only excelled in some parts of the Netherlands. Besides the common articles for personal and domestic use, Prussia manufactures the finest and most beautiful damask services for the table, which are generally preferred to all others, in the higher circles, throughout nearly the whole of Europe. Before the continental war, the produce of the linen from Silesia amounted to L.1,689,915 sterling, of which L.970,000 was destined for foreign consumption. In the western provinces the linen cloth is principally made for home consumption. Large quantities of linen goods were formerly exported to Spain, and from Cadiz to the former Spanish colonies in South America; but that trade was destroyed by the submission of the continent to the prohibitions imposed by Napoleon, and has not since been recovered, as the markets are now supplied by Great Britain and Ireland.

The increase of Merino sheep has given a great stimulus to the fine woollen manufactures, especially to those in the newly-acquired provinces on the French frontiers, where some of the best superfine cloths that Europe can exhibit are made. In the late department of the Roer, or, as it is now denominated, the circle of Aachen, in the towns of Eupen, Aachen, Montjoie, Stolberg, and Montmedy, fine cloths and cassimeres are manufactured, which are estimated to amount to a million and a half sterling, and afford employment to upwards of 50,000 workmen, as well as to every kind of machinery that has been invented in England or in any other country. The cloths for the dress of the middle and lower classes are wholly made within the kingdom from their native wools. The woollen manufactories throughout the kingdom, on an average from 1829 to 1831, yielded annually about L.4,525,000 sterling.

Cotton goods have been made to a considerable extent. In some instances the yarn is spun in foreign countries, and the weaving, bleaching, and dyeing only executed in Prussia; and as the raw material, a foreign article, cannot be procured so cheap as in England, this branch of industry has much diminished since the general peace. During the period from 1829 to 1831, the cotton manufactures produced to the state about L.4,250,000 sterling yearly, after deducting the prime cost of the materials. The iron manufactures are more than sufficient for the domestic consumption, and furnish to the value of about L.300,000 sterling for exportation. There are three hundred paper-mills, which furnish the common kinds of paper in quantities sufficient for the consumption of the country; but the finer sorts are supplied either from Great Britain or from France. Silk goods, and mixed goods either of silk and cotton or silk and woollen, are chiefly made in the capital, in which, and in some other places, they give employment to about 20,000 looms. The various kinds of leather are made from skins produced at home, as far as they are found sufficient, and the deficiency is supplied from Buenos Ayres, through the intervention of Britain or Spain. Copper and brass wares for all domestic purposes are made, partly from the copper and calamine of their own mines, but chiefly with copper furnished by other countries. The amount of these wares is estimated at about L.200,000 sterling. Tobacco, snuff, sugar, soap, candles, cabinet-ware, earthen-ware, porcelain, tin goods, and almost every article of common consumption, are made within the kingdom. As no wine is made in the eastern part of Prussia, the common beverage is either beer or brandy, distilled from the native grains. The establishments for brewing and distilling are consequently very numerous; but none of them approach in magnitude to the larger concerns of a similar kind in England. The whole quantity of beer brewed is between four and five million casks, of fifty gallons each. The consumption of corn brandy is upwards of 8,000,000 gallons. In the larger cities the letter-founders, printers, engravers, musical, optical, and mathematical instrument makers, gold and silver smiths, jewellers, watchmakers, and other similar artificers, are to be found as numerous and as skilful as in the other countries on the Continent. With regard to the respective trades, Prussia contains, on an yearly average, 328,317 mechanics, artisans, and craftmen, with 181,054 assistants. The number of printing-offices is 327, with 709 presses; tile and brick manufactories, limekilns, glass-houses, tar manufactories, 5406; iron, copper, and other smelts, 1932; watermills, 13,949, with 22,693 lets; 10,451 windmills, 1184 mills worked with horses, and 9422 oil-mills; fulling-machines, tan, saw, and paper-mills, looms for shawls, stockings, and tissue of all sorts, 87,558; 5614 drivers of teams for the transportation of goods by land, employing 11,994 horses; the licensed hotels, cook-shops, taverns, wine and spirit retailers, amount in the whole country to 74,721.

Foreign commerce. The commerce of Prussia with foreign nations is much less than the extent of the country and the number of the inhabitants would lead us to expect. It is loaded with many restrictions, which, however necessary they may be deemed in a fiscal view, are vexatious and harassing. The commerce by land, by internal navigation, is principally with Austria and Russia. From Austria she receives salt and wine, and sends linen-yarn in exchange. From Russia she draws hemp, corn, hides, tallow, and some other

Statistics. productions of the soil, and sends in return both linen and woollen cloths. The provinces on the Rhine carry on very considerable traffic in wine and manufactured goods with the adjoining provinces in the kingdom of the Netherlands, and with several of the states of Germany.

As Prussia possesses no seaports except on the Baltic, and as none of its harbours enjoy good entrances, or are calculated to receive ships of a great draught of water, there is very little commerce carried on beyond the limits of Europe.

The greater part of the exports from Prussia are conveyed by foreign ships, of which the British exceed in number those of all other nations together. Dantzig, once a Hanse town, and the seat of extensive commerce, has much declined since it has become subject to Prussia, notwithstanding its favourable situation for exporting the productions raised on the banks of the Vistula and its tributary streams. It still, however, exports corn, wood, potashes, linen, wool, wax, honey, horse-hair, and feathers; and imports colonial wares and some few manufactured goods. The vessels which entered the port of Dantzig during the year 1835 amounted to 621, having a tonnage of 94,534; and those which cleared out to 621, having a tonnage of 95,079. The imports by sea during the same year amounted to L.495,909, and the exports to L.373,700. Königsberg exports corn, but the vessels to be loaded with it can approach no nearer than to Pillau. The number of vessels inwards during the year 1835 amounted to 246, and the tonnage to 18,028; those outwards to 249, and the tonnage to 18,786. The imports during the same year amounted to L.265,203, and the exports to L.275,642. Elbing has lately increased by dividing the commerce with Dantzig, and the articles imported and exported are of the same description as constitute the trade of that city. Memel is the largest exporting city, and corn, ship-timber, and masts, pot and pearl ashes, with flax-seed, are its chief commodities. Stettin has the greatest portion of the import trade, as, from its position on the Oder, it is best calculated to receive colonial produce, and forward it to the capital and to the centre of the kingdom. It is also the port in which the greater part of the vessels for the fisheries are equipped. The estimated value of its exports in 1834 amounted to L.374,800, in 1835 to L.280,000; and that of its imports in 1834 to L.714,050, and in 1835 to L.841,670. Stralsund, though it possesses a good harbour, has but little trade, from being destitute of water-communication with the interior of the kingdom. The other ports of Prussia, Colberg, Rugenwalde, Stolpe, Barth, Swinemunde, and Wolgast, carry on some trade, and though not to a great extent, it is valuable, from being almost exclusively conducted in national vessels. The whole exports of Prussia, both by land and by sea, amount to about L.4,500,000 sterling, the whole of the imports to about L.3,750,000; but in the latter is not included the products of their own oil and herring fisheries. The duties on imported goods vary from ten to twenty-five per cent. *ad valorem*, besides an additional tax, never exceeding ten per cent., for the consumption of imported goods. With very few exceptions, all exportations are duty free. For transit goods a certain import and export duty is paid. According to the commercial treaty with Great Britain, concluded 2d April 1824, a perfect reciprocity is established respecting the duties levied on ships belonging to either country visiting the ports of the other. Coasting is only permitted to ships belonging to Prussia. Statistics.

A Statement of the Extent of each of the States composing the German Commercial Union, in German and English Square Miles, in the month of October 1836.

	Square Miles.			
The German Commercial Union, in its present extent, contains a surface of 174,627·34 square miles, which is thus distributed :—	German.		English.	
1. Prussia (kingdom of), without the principality of Neufchatel, but including those countries whose population is added to this state upon the division of the revenue being made, and who are indemnified by Prussia	5,157	21	109,126	56
2. Bavaria (kingdom of), including some Saxon enclaves	1,477	26	31,258	82
3. Saxony (kingdom of)	271	68	5,748	74
4. Wurtemberg (kingdom of), including the principalities of Hohenzollern-Sigmaringen and Hohenzollern-Heckingen	385	15	8,149	77
5. Hesse-Cassel (electorate of)	182	10	3,853	23
6. Hesse (grand duchy)	179	25	3,792	93
7. The countries belonging to the Thuring confederation	233	49	4,940	64
8. Baden (grand duchy), including a part of the principality of Hohenzollern-Sigmaringen	279	54	5,915	06
9. Nassau (duchy)	82	70	1,749	93
10. Frankfort (free town of)	4	33	91	62
Total	8,252	71	174,627	34

	Square Miles.			
The frontiers comprise an extent of 4,896·65 square miles, which, by the last returns, namely, in the year 1836, are thus divided :—	German.		English.	
1. Prussia	774	99	3,564	95
2. Bavaria	151	56	697	17
3. Saxony	58	0	266	80
4. Baden	60	50	278	30
5. Hesse-Cassel	16	40	75	44
6. Wurtemberg	3	10	14	26
Total	1,064	49	4,896	65

Statistics.

A Recapitulation of the States composing the Prussian Commercial Union, with the Population of each State.

Statistics.

States of the Prussian Confederation.	Surface in German Square Miles, Fifteen to a Degree.	Number of Inhabitants.	Deductions for Military and Independent Districts.	Number of Inhabitants, by which the Revenue is regulated.	Per-Centage Proportion on the Joint Revenue.
1. Prussia and its dependencies.....	5,157·21	13,800,126	109,473	13,690,653	54·56
2. Bavaria	1,477·26	4,252,813	1,695	4,251,118	16·94
3. Saxony.....	271·68	1,595,668	...	1,595,668	6·36
4. Wurtemberg.....	385·15	1,631,779	...	1,631,779	6·50
5. Electorate of Hesse.....	182·10	700,327	59,653	640,674	2·55
6. Grand duchy of Hesse.....	179·25	769,691	...	769,691	3·07
7. Thuringia.....	233·49	908,478	...	908,478	3·62
8. Grand duchy of Baden	279·54	1,232,185	...	1,232,185	4·91
9. Duchy of Nassau.....	82·70	373,601	...	373,601	1·49
	8,248·38	25,264,668	170,821	25,093,847	100·
10. The free city of Frankfort.....	4·33	60,000	...	60,000	...
	8,252·71	25,324,668	...	25,153,847	...

Government.

The government of Prussia is an unlimited monarchy; for though in some of the provinces, by ancient custom, the states still exist, they seldom assemble, and only for such inferior purposes as regulating the debts or expenses of their respective provinces. They have no legislative powers, and scarcely even the right to make representations to the monarch. By the act of the 5th of June 1823, an assembly was instituted, composed of provincial members, to meet alternately at Berlin, Königsberg, Dantzig, or Stettin. The qualifications for membership are ten years' possession of an estate, connection with one of the Christian churches, to be thirty years of age, and to have a blameless reputation. The electors must be twenty-four years of age, and no one can give his vote by proxy. The crown is hereditary in the oldest member of the royal family, whether male or female. The monarch is of age when he arrives at his eighteenth year. The natural guardian of the royal minor is the nearest and oldest princely relation of the house. The king professes the evangelical religion, but he may, if he chooses, follow the Roman Catholic faith. The sole executive and legislative power is vested in him, and his authority is less restrained by the ancient privileges and usages of his subjects than that of any other European monarch. The administration is vested in a council of state, consisting of members of the royal family, and of the ministers of foreign affairs, of the finances, of justice, of public instruction, of trade, of the public debt, of police, and of war. The state chancellor is president of this council, and to him all the heads of the different departments are accountable, and make their weekly reports. He is uncontrollable by his colleagues, and directed solely by the king. In the details of the administration, through all the inferior departments there is much simplicity, and a degree of economy in remunerating public services which scarcely finds a parallel under any other government.

The canton of Neufchatel enjoys peculiar privileges, and a form of government altogether different from that by which the rest of the Prussian dominions is regulated. It forms a part of the Swiss confederation; and though it acknowledges the king of Prussia as its sovereign, his influence is very inconsiderable. He receives only the revenue of some domains, and a very moderate land-tax, which cannot be augmented. The inhabitants who choose the military profession may enter into the service of any state not actually at war with Prussia. Every profession and every trade are free, and no customs are levied, and no duties imposed on any goods which enter or leave the territory.

Knighthood.

The orders of knighthood established in Prussia are, the order of the black eagle, founded 18th January 1701, by Frederick I.; the order of the red eagle, founded 1734, by the Margrave Frederick Charles of Baireuth; the order *pour le mérite*, founded 1740, by Frederick II.; the royal Prussian new order of St John, founded 1812, in commemoration of the ancient order of St John, dissolved 1811. During the war with France in 1813 and 1815, the Iron Cross was given to those who either had actually fought against the enemy, or else done some meritorious act, either civil or military, during that period. The king also founded, in 1814, the order of Louise for females who distinguished themselves in the cause of their country during the war. There are, besides, various other marks of distinction given for different degrees of military service. All orders are distributed by the king alone.

Revenues.

The revenues of Prussia are derived from taxes upon the land, upon persons, upon patents, and licenses, which are denominated direct contributions; and from an excise, or rather a custom-duty, on foreign productions. A small sum is derived from stamped paper. In those provinces which were taken from the French empire, the taxes on land, on trades, on doors and windows, as then established, are still continued, and will remain till the whole of these provinces are brought under the simple regulations established in the other dominions. More than one fourth of the revenue of the monarchy is derived from the royal domains, and the hereditary rights or royalties which are exercised over the mines, the salt-springs, the game, the coinage, the posting, and the postage, with some other branches. Though the higher branches of the administration appear to be benefited by parsimony in the salaries, yet in the inferior departments it appears to be injurious, as the petty officers, who are very numerous, are too poor to refuse bribes; and they are not deterred by the apprehension of dismission from offices whose fair emoluments scarcely equal the wages of a day-labourer.

Statistics. *The following is a Statement of the Average Annual Income of the Kingdom of Prussia, under its several heads, from* 1829 *to* 1834, *and of the same prospectively from* 1834 *to* 1837, *inclusive.* Statistics.

SOURCES.	From 1829 to 1831.	From 1832 to 1834.	From 1835 to 1837.
	P. Dollars.	P. Dollars.	P. Dollars.
1. From crown-lands and forests, after deducting the sum set apart for the king's civil list	4,524,000	4,280,000	4,212,000
2. From sold and regulated crown lands, for the more speedy extinction of the national debt	1,000,000	1,000,000	1,000,000
3. From mines, melting-houses, salt-works, and the porcelain manufactory at Berlin	1,014,000	714,000	717,000
4. From the post-office	1,100,000	1,100,000	1,200,000
5. From the lottery	684,000	574,000	669,000
6. From taxes, licenses, customs, excise, and salt monopoly	41,850,000	43,351,000	43,530,000
7. From the principalities of Neufchatel and Lichtenberg	26,000	26,000	80,000
8. From other minor revenues and receipts	598,000	242,000	332,000
Total	50,796,000	51,287,000	51,740,000

Before the reign of the father of the present king, Prussia had no public debt whatever, but usually a sufficient accumulation of money to meet any emergency that might occur. The present king, by economy and regularity, had reduced the debt which his predecessor had incurred, when the rupture with Napoleon in 1806 drew forth all his resources, and until the year 1815 the debt continued to increase. Since the restoration of general peace, due measures have been taken for the reduction of it. On the 12th of January 1833 it amounted to L.25,678,365, including a loan of L.6,000,000 from British subjects, and the debts assumed upon the cessions of territory from Sweden, Denmark, and Saxony. Besides this national debt, many of the corporate bodies have borrowed considerable sums, which were presented to the government in the most critical periods, and which are in the progress of being liquidated from their own incomes.

The expenditure of the government is upon a very low scale. No court can be less expensive than that of Berlin, and no monarch can be less attentive to his personal gratifications than the present king, who, like his predecessor, Frederick II., appropriates but a small portion of his patrimonial income to his private purposes, devoting it principally to the service of the state. The average annual expenditure from 1829 to 1837 inclusive was as follows:

HEADS.	From. 1829 to 1831.	From 1832 to 1834.	From 1835 to 1837.
	P. Dollars.	P. Dollars.	P. Dollars.
1. Administration of the national debt	10,937,000	10,890,000	8,918,000
2. Pensions, claims, and life annuities	3,158,000	2,887,000	2,550,000
3. Indeterminable annuities	277,000	391,000	963,000
4. The king's cabinet, the ministry of state office, board of control and of the public treasure, the mint, state and provincial records office, secretary of the council of state, heralds' office, statistical department	288,000	298,000	308,000
5. The ministry for clerical and medical affairs, and of public instruction	2,347,000	2,489,000	2,683,000
6. The home department, including the board of trade from 1829 to 1831	4,883,000	2,067,000	2,357,000
7. The board of trade, of works and roads	...	3,103,000	4,221,000
8. The ministry of foreign affairs	586,000	586,000	681,000
9. The army	22,165,000	22,798,000	23,462,000
10. The treasury	263,000	254,000	253,000
11. The ministry of justice	1,823,000	1,850,000	2,061,000
12. The provincial administration	1,830,000	1,788,000	1,766,000
13. The central and provincial studs	163,000	175,000	167,000
14. Extraordinaries	2,076,000	1,711,000	1,350,000
Total	50,796,000	51,287,000	51,740,000

In 1832 the Prussian army stood as follows:—

Royal guards—Infantry	16,280	
... Cavalry	3,820	
		20,000
Line—Infantry	118,540	
... Cavalry	19,100	
		137,640
Artillery and pioneers		17,720
		175,360
Landwehr		153,420

The regular ranks are filled by a conscription, which compels every young man, as he arrives at twenty years of age, to serve for a limited period. If the conscript can purchase his arms and accoutrements, and pay a small sum, he may at the end of one year pass into the landwehr, which is composed of this class of men, and of all others between twenty-five and forty years of age. In time of peace the landwehr is exercised but one day in the year, but in war it becomes a disposable force, and is marched wherever its services may be deemed necessary. The other militia force, the landsturm, is composed of all males capable of bearing

Statistics. arms, above forty years of age. This force is only called out in periods of great emergency, and then its duty is entirely domestic, being confined to guarding prisoners and maintaining internal tranquillity. But it is unnecessary to enlarge on this subject, as it is pretty fully treated of in the article ARMY, to which the reader is referred.

Soldiers who are maimed or severely wounded are admitted either into the hospitals at Berlin, Stolpe, &c. or into one of the twenty-four invalid companies, and receive board, lodging, clothes, and necessary medical attendance. Those who are less severely wounded, or who in consequence of their military service are incapable of entirely earning their livelihood, receive pensions proportioned to circumstances.

To the military establishment belong the institution for the education of the children of soldiers in Stralsund and Annaburg, and the Military Orphan Hospital in Potsdam, where the orphans of soldiers are maintained and educated.

The principal fortresses in the kingdom are, in the province of Prussia, Dantzig, with Weichselmunde, Graudentz, Pillau, and Thorn; in Pomerania, Colberg and Stettin; in Brandenburg, Kustrin and Spandau; in Silesia, Glutz, Glogau, Kosel, Neize, Schweidnitz, and Silberberg; in Saxony, Magdeburg, Wittenberg, Torgau, and Erfurt; in Westphalia, Minden; in the province of the Rhine, Wesel, Cologne, Gulick, Saarlouis, and Ehrenbreitstein, with Coblentz.

Administration of laws and police. Prussia enjoys a peculiar code of laws, founded by Frederick the Great upon the ancient customs and usages of the people, and finally reduced to a more regular system in 1794. The magistracy in the rural districts is still a patrimonial right, vested in owners of particular estates; but the power formerly possessed by them has been contracted within narrower limits than formerly. The decision of these lower courts is not final, except in very trifling cases; and an appeal may be made to the tribunals of the second instance, which are established in the several provinces, and to whom is attached the superintendence of the colleges for imparting legal knowledge to pupils. To these tribunals of the second instance, or *Oberlandesgerichten*, is intrusted the duty of promulgating the laws, of watching over the interests of lunatics and minors, as well as of deciding processes. They are usually divided into two portions, one of which attends to the appeals from the inferior courts, and the other pronounces sentence on such civil and criminal cases as originate in them. From all the Oberlandesgerichten appeals may be brought before the High College of Justice in Berlin, whose decisions are final. The Prussian system of law is more simplified than most of those of feudal origin, and in its practice it is expeditious, economical, and uniform. The police is under separate jurisdictions; and in the country the *landraths* resemble in some measure our petty sessions of justices of the peace. In the cities there are peculiar boards appointed, under whose direction the regulation of buildings, sewers, and the supplies of water and of food, are placed. The police has the superintendence of the examination of those who are licensed to practise the medical profession, of the insurance offices against losses by fire, and of the engines and other implements to prevent fire from extending. To this is added the keeping a watchful eye on all individuals who have no visible means of subsistence. In all the cities the police is mildly and regularly administered, with more attention to the prevention than the punishment of crimes.

As to the amount of crime, it varies considerably in the different provinces. It appears from the returns, that crimes are most rare in the Protestant districts, and most common in those where the numerous festivals and holidays of the Roman Catholic Church are observed. It is certain, besides, that the most industrious countries are those in which there are fewest Romanists. In the territories of Aix-la-Chapelle one individual out of every 60,000 inhabitants has been found guilty of murder; in the province of Saxony and the country of Munster, one out of every 35,000; in the district of Marienwerder, one out of every 25,000; in Pomerania, one out of every 4760; in the towns of Cologne, Munster, Dusseldorf, and Aix-la-Chapelle, one out of every 400. As to the number of thefts and robberies, there is in Pomerania one for every 6432 inhabitants; in Western Prussia, Silesia, or Eastern Prussia, one for every 3000; in the neighbourhood of Coblentz and Trêves, one for every 800; in Cologne, Dusseldorf, Munster, and Aix-la-Chapelle, one for every 400. Statistics.

Public instruction. Few of the nations of Europe have, within the last two centuries, exceeded Prussia in the number and eminence of its men of learning, or in the variety and excellence of its establishments for the promotion of science and literature. In no other country is the instruction of the lower classes so sedulously provided for, and in none are there so few persons who are ignorant of the first rudiments of knowledge. In Prussia, as in other countries, public instruction long formed a part of the business of the minister of the interior; but in 1819 a special department of administration was devoted to this object. The minister of public instruction enjoys a rank and authority equal to those of any of his colleagues. Under him is a numerous council, divided into three sections; one for church affairs, composed of a certain number of councillors, chiefly ecclesiastics, with a director at their head; another for public instruction, also composed of a certain number of councillors, almost all laymen, with a director; and a section for medicine, with its councillors and director. All the members of this council receive salaries from the state. The same individual may belong to two sections, but he can in no case receive more than the salary of one. In each of the ten provinces into which Prussia is divided, under the direction of the supreme president of the province, is an institution called the Provincial Consistory, which is connected with and dependent upon the ministry of public instruction, and having its internal organization formed upon the same model. All the members are nominated directly by the minister of public instruction, and they are remunerated for their labours. Their duty is more peculiarly to superintend the secondary instruction, the gymnasia, and higher burgher schools. Every *gemeinde* (parish) must by the law of the land have a school; and the pastor or curate is, in virtue of his office, the inspector of this school, associated with whom is a committee composed of some of the most considerable persons of the parish. In the urban parishes the magistrates form a higher committee or board, which presides over all these schools with their several committees, and arranges them into one harmonious system. There is, moreover, in the chief town of the circle another inspector, whose authority extends to all the schools of that circle, and who corresponds with the local inspectors and committees. In the *regierung* (regency) of every department there is a special councillor for the primary schools, called *schulrath* (school councillor), who acts as a link between the public instruction and the ordinary civil administration of the province. He inspects the schools, quickens and keeps alive the zeal of the school-inspectors, school-committees, and the schoolmasters. He conducts the correspondence relative to schools in the name of the regency, with the local and superior inspectors, as well as with the provincial consistories and the minister of public instruction. Like all his colleagues, he is a paid officer.

In Prussia the state imposes on all parents the strict obligation of sending their children to school, unless they can prove that they are giving them a competent education at home. Children must remain at school from their seventh to their fourteenth year inclusive.[1] Neglect of this duty ex-

[1] Five is the age fixed by the fundamental law, but seven is that at which education is rigidly enforced.

Statistics.

poses parents or guardians to punishment by fine or imprisonment. The hours of lessons in the elementary schools are arranged in such a manner as to facilitate to parents the execution of this law, and at the same time not to deprive them entirely of the assistance which their children might afford them in their labours; and care is everywhere taken to furnish necessitous parents with the means of sending their children to school, by providing them with the things necessary for their instruction, or with such clothes as they stand in need of. Every parish, however small, is bound to have an elementary school, accomplishing at least the most indispensable part of the scheme of instruction prescribed by law; and every town is bound to have at least one burgher school or more, according to its population. In certain cases where a parish is absolutely unable to furnish the means of an elementary school of itself, several villages may unite together into one school association. The law provides also a suitable income for teachers, and certain provision for them when they are past service, a suitable building for the purposes of teaching and of exercise, furniture, books, &c. and pecuniary assistance for the necessitous scholars. The gymnasia, and other establishments of a similar kind, are principally supported by the general funds of the state, or of the province; but the inferior schools in towns and villages are supported by the towns, and by the school associations in the country. If, however, a town is unable out of its own resources to support the lower grade of instruction of which it stands in need, aid is given to it from the school funds of the department to which it belongs. The necessary funds are provided by an assessment levied on all the householders in the parish.

Every complete elementary school comprehends the following objects:—Religious instruction; the German language; the elements of geometry, together with the general principles of drawing; calculation and practical arithmetic, the elements of physics, geography, general history, and especially the history of Prussia; singing, writing, and gymnastic exercises; the simplest manual labours, and some instruction in husbandry. The instructions in religion, reading, writing, arithmetic, and singing, are indispensable in every school; and no school is considered as complete unless it fulfil the whole scheme of instruction just marked out. Next to the village are the burgher schools, where, in addition to the branches taught in the elementary schools, the pupils are instructed in Latin, and prepared for admission into institutions called gymnasia, similar to our grammar schools of Winchester, Eton, Westminster, and Edinburgh. In these institutions classical learning is pursued to a great extent, as preparatory to admission into the universities; some of them are under the direction of the Protestants, others under that of the Catholics, and some few under a combined direction of both sects. They have, according to their extent, from four to twelve masters; and the pupils are divided into five or six classes, the lower of which differ but little in their instructions from the burgher schools. In the larger and middle-sized cities schools are established for the instruction of the females, with which, in Silesia, are combined, amongst those of the lower class, the teaching the delicate art of lace-making.

The religious instruction given in the Prussian schools is always adapted to the doctrines of the church to which the school belongs. The children of a different persuasion, however, are subjected to no kind of annoyance or constraint on account of their particular creed. No attempt is made to proselytise them; and they are not obliged, against the will of their parents, or their own, to attend the religious instruction or exercises of the school, but private masters of their own creed are charged with their religious education. Every scholar of an elementary school must, when he leaves it, receive a certificate as to his capacity, and his moral and religious dispositions, signed by the masters and the school-committee. These certificates are always presented to the clergyman before admission to the communion, to master-manufacturers or artisans on being bound apprentices, or to housekeepers on entering service. Statistics.

In order to provide schools with proper masters, primary normal schools have been instituted, in which those intended for the office of teachers receive instruction in the appropriate branches of education, and especially in the theory and practice of teaching. Pecuniary assistance is also given to a certain fixed number of poor scholars of good promise. The expenses of these establishments are defrayed partly by the general funds of the state, and partly by the departmental funds for schools. The age of admission is from sixteen to eighteen years, and the course of study extends to three years; and during that time no pupil is called out to active service in the army. Any person of mature age and irreproachable character may be appointed to the office of schoolmaster, if he is found, on examination, to possess the necessary qualifications; but preference is given to the pupils of the primary normal schools. The election of the schoolmasters for country schools is vested in the committee of superintendence; for town schools supported by a public rate, in the municipal authorities; but in all schools in towns founded by the king, the election to masterships is conducted by the provincial consistories. The election must, however, be ratified by royal authority before the teacher can be installed in his office, or be entitled to its revenues. Able and diligent schoolmasters are encouraged by promotion to places of a higher class, and even, on particular occasions, by extraordinary rewards; neglect of duty, and other offences, are punished by reprimands, fines, and deprivation of employment. Public schools are the basis of popular instruction in Prussia, but private schools are not prohibited. Those, however, who wish to establish schools for private education must undergo an examination, and receive a license from the provincial consistory; and the establishment is placed under the special supervision of one of the members of the school-committee of the town or district in which it is situated.

In 1831 it was estimated that, in Prussia, the children of from one day to fourteen years old amounted to 4,767,072. It is a rule in statistics, that out of a hundred children, those between seven and fourteen form three sevenths, which gives out of every hundred, forty-three of an age to go to school (or, to give the minutest fractions, 42,857 in 100,000), and consequently in Prussia 2,043,030. Now it has been found, according to the accurate calculation of the attendance lists, that the actual number of children who attended the public primary schools in the year 1831 was 2,021,421, exhibiting the slight difference of only 21,609 between the real and the normal number. And even this will vanish, if we consider that these calculations are founded only on the public primary schools, and do not include the private ones; and that no account is taken of the children educated at home, nor of the boys belonging to the lower classes of the gymnasia. Taking these circumstances into account, it is evident that the number of children under fourteen who receive in one way or another the benefits of education, is not only equal to three sevenths of the population, but that it must actually exceed that number; a circumstance which can be explained only by the fact, that in the most civilized provinces of Prussia the taste for instruction is so generally diffused, that parents anticipate the age fixed by law for sending their children to school. The following statement will show the relative proportion in each province, of the total number of children attending public schools:—

At the end of the year 1831, in every 100,000 children, the number who attended public schools was, in the province of Saxony, 54,515; in that of Westphalia, 47,386; in that of Brandenburg, 45,814; in that of Silesia, 45,042; in that of the Rhine, 41,002; in that of Pomerania,

Statistics. 40,775; in that of Prussia, 39,651; and in that of Posen, 22,283. The difference in the proportion of boys and of girls is inconsiderable. Out of 2,021,421 children attending school, there were, in 1831, 1,044,364 boys, or 43,694 in 100,000; and 977,057 girls, or 41,106 in 100,000. The total number of primary public schools was 22,612; of these, 21,789 are elementary and 823 middle schools, of which 481 are for boys and 342 for girls. The elementary schools are attended by 987,475 boys and by 930,459 girls, and the middle schools by 56,889 boys and by 46,598 girls. For the 22,612 public schools there are in all 27,749 masters and mistresses, who are distributed as follows, viz. 21,789 elementary schools, with 22,211 regular masters, 694 regular mistresses, and 2014 assistant masters and mistresses; 481 middle or burgher schools for boys, with 1172 regular masters and 360 assistant masters; 342 middle or burgher schools for girls, with 633 regular masters, 289 regular mistresses, and 471 assistant masters and mistresses.

In the year 1831 there were in Prussia thirty-three great primary normal schools, each of which contained from forty to 100 pupils; their total expenditure was L.16,583, and the grants from the state amounted to L.13,260. Besides these, there are a considerable number of small normal schools. The annual sum paid by the public treasury for the elementary and the burgher schools throughout Prussia amounted in 1831 to L.34,520. Statistics.

As primary instruction belongs chiefly to the department and the parish, and secondary instruction to the provinces, so the universities are under the exclusive care of the state, and, like the universities in the other parts of Germany, are either endowed, or the expenses of the professors and the libraries are defrayed by the government. The course of study is left much to the choice of the students, and is therefore too much influenced by the temporary popularity of particular professors. The means of instruction in every branch of science and literature are abundantly furnished; and, in spite of the want of discipline which generally prevails, the foundation is laid in them of those eminent acquirements in which the students have afterwards distinguished themselves in the various walks of science and literature. The principal universities are those of Berlin, Breslau. Halle, Bonn, Königsberg, Munster, and Greifswald.

A Statement of the Average Number of Students in each Branch of Science, distinguishing Natives from Foreigners, in the several Universities and Catholic Seminaries of Prussia; also the Number of Professors in each, and the Average Number of Students to each Professor, in the Year 1834.

NAMES.	AVERAGE NUMBER OF STUDENTS.																		Total Number of Professors.	Average Number of Students to each Professor.
	Evangelical Theology.			Catholic Theology.			Jurisprudence.			Medicine.			Philosophy.			Total.				
	Natives.	Foreigners.	Total.	Natives.	Foreigners.	Total.	Natives.	Foreigners.	Total.	Natives.	Foreigners.	Total.	Natives.	Foreigners.	Total.	Natives.	Foreigners.	Total.		
Berlin.....	439	126	565	...	...	...	442	140	582	246	141	387	192	106	298	1319	513	1832	149	12·3
Breslau.....	203	3	206	213	1	214	224	5	229	108	5	113	111	2	113	859	16	875	72	12·1
Halle.....	412	78	490	...	...	...	99	20	119	78	33	111	48	9	57	637	140	777	74	10·5
Bonn.....	77	26	103	179	9	188	235	37	272	136	19	155	97	20	117	724	111	835	71	11·7
Könisberg...	152	10	162	...	...	...	80	5	85	71	11	82	96	5	101	399	31	430	60	7·1
Munster.....	...	...	...	146	38	184	...	...	...	...	...	...	67	4	71	213	42	255	16	16·
Greifswald...	80	6	86	...	...	...	36	1	37	60	6	66	14	1	15	190	14	204	41	5·
Total.....	1363	249	1612	538	48	586	1116	208	1324	699	215	914	625	147	772	4341	867	5208	483	10·7

Statement of the Total Average Number of Students in each Branch of Science, distinguishing Natives from Foreigners, in the Universities of Prussia, in each Half Year from 1830 *to* 1834.

YEARS.		Evangelical Theology.		Catholic Theology.		Jurisprudence.		Medicine.		Philosophy.		Total.		
		Natives.	Foreigners.	Natives.	Foreigners.	Natives.	Foreigners.	Natives.	Foreigners.	Natives.	Foreigners.	Natives.	Foreigners.	Total.
1830	Summer..	1750	394	660	153	1348	202	496	196	589	157	4843	1102	5945
	Winter....	1787	411	656	107	1353	241	502	203	667	175	4965	1137	6102
1831	Summer...	1657	311	650	103	1194	160	495	163	646	131	4642	868	5510
	Winter ...	1689	312	642	79	1308	213	553	176	656	163	4848	943	5791
1832	Summer...	1537	206	620	82	1163	130	546	165	683	114	4549	697	5246
	Winter....	1497	245	628	59	1219	164	579	196	705	131	4628	795	5423
1833	Summer...	1468	263	596	51	1170	205	608	185	716	146	4558	850	5408
	Winter....	1386	283	608	50	1246	243	684	216	646	151	4570	943	5513
1834	Summer...	1397	257	546	46	1169	213	717	221	602	154	4431	891	5322
	Winter....	1328	243	529	50	1062	200	681	210	645	140	4245	843	5088

The state makes annual allowances for the support of the various departments of the universities.

I.—The University at Berlin.

1	Medical establishment	Ry. 1500	0	0
2	Chirurgic medical ditto	6700	0	0
3	Poleklin ditto	2000	0	0
4	Midwife assistant ditto	5468	0	0
5	University widows' fund	5301	0	0
6	Theological seminary	630	0	0
7	Philological ditto	500	0	0
8	University garden	500	0	0
9	Observatory	100	0	0
10	Chemical laboratory	400	0	0
11	Herbarium	Ry. 1200	0	0
12	Anatomy and the anatomical museum	3167	22	6
13	Cabinet of minerals	1520	0	0
14	Ditto of chirurgical instruments and bandages	430	0	0
15	Mathematical-physical apparatus	500	0	0
16	Seminary for schools of learning	2000	0	0
17	Establishment for the improvement of cameralists	1000	0	0
18	Library	500	0	0
19	Zoological museum	2994	0	0
20	Botanical gardens	11,228	0	0
21	Royal library	15,102	15	0
	(@ 6 Ry. 25 sgr. L.9181. 3s. 1d.)		62,741	7 6

Statistics.

II.—University at Bonn.

1	Library	Ry.	4621	15	0
2	Evangelic-theological seminary		400	0	0
3	Catholic ditto ditto		300	0	0
4	Convictorium for the Catholic theological students		7589	11	5
5	Medical establishment		4017	0	0
6	Chirurgic-medical ditto, united to the cabinet of chirurgical instruments and bandages		4091	20	0
7	Midwife-assistant establishment		1773	10	0
8	Anatomy and the anatomical museum		1500	0	0
9	Botanic garden, including 60 Ry. for the guard		2560	0	0
10	Museum for natual history		1150	0	0
11	Technic-chemical laboratory		350	0	0
12	Technological cabinet		100	0	0
13	Physical ditto		400	0	0
14	Pharmacitic laboratory		50	0	0
15	Pharmacologic apparatus		50	0	0
16	Seminary for the science of nature		400	0	0
17	Museum of arts		200	0	0
18	Philologic seminary		500	0	0
19	Academical widow and maintenance institution		3571	15	0
	(@ 6 Ry. 25 sgr., L.4920. 13s. 9d.)				33,624 11 5

III.—University of Breslau.

1	Library	Ry.	5130	0	0
2	Evangelic-theological seminary		300	0	0
3	Catholic ditto ditto		300	0	0
4	Homilitic establishment		50	0	0
5	Academical ditto for sacred music.		820	0	0
6	Medical clinicum		2569	6	8
7	Chirurgical ditto		2000	0	0
8	Anatomical establishment		1898	6	0
9	Instruction of midwifery ditto		400	0	0
10	Midwife-assistant ditto		600	0	0
11	Philological seminary		300	0	0
12	Observatory		370	0	0
13	Museum for the historical science of nature		868	0	0
14	Botanic garden		2610	0	0
15	Mineralogic cabinet		200	0	0
16	Physical apparatus		368	0	0
17	Mathematical-physical ditto		80	0	0
18	Chemical laboratory		372	0	0
19	Collection of moulds and agricultural apparatus		50	0	0
	(@ 6 Ry. 25 sgr., L.2822. 5s. 1d.)				19,285 12 8

IV.—University of Greifswald.

1	Library	Ry.	1715	0	0
2	Medical ambulation clinicum		200	0	0
3	Chirurgic ditto ditto		46	0	0
4	Medical chirurgic lazaretto		650	0	0
5	Institution for the instruction of midwifery and midwife assistant		380	0	0
6	Academical widows' fund		227	0	0
7	Establishment for free boarders		2924	0	0
8	Botanic garden		1010	0	0
9	Riding school		150	0	0
10	Astronomical cabinet		60	0	0
11	Procuring of chemical apparatus		160	0	0
12	Anatomical zootomic museum		677	0	0
13	Cabinet of minerals		30	0	0
14	Zoological museum		1000	0	0
15	Cabinet of physical instruments		60	0	0
16	Ditto of agricultural moulds		45	0	0
17	Theological seminary		67	0	0
	(@ 6 Ry. 25 sgr., L.1375. 15s. 1d.)				9,401 0 0

V.—University at Halle.

1	Library	Ry.	2820	0	0
2	Botanic garden		1090	0	0
3	Midwife-assistant establishment		1000	0	0
4	Medical and ambulatory clinicum		3040	0	0
5	Chirurgical ditto		1210	0	0
6	Anatomical and zoological museum		1470	0	0
7	Observatory		240	0	0
8	Cabinet of natural curiosities		885	0	0
9	Ditto of minerals		280	0	0
10	Physical chemical laboratory		520	0	0
11	Philologic seminary		530	0	0
12	Cabinet of arts		115	0	0
13	Riding school		280	29	1
14	Institution for sacred music		130	0	0
	(@ 6 Ry. 25 sgr., L.1991. 17s. 9d.)				13,610 29 1

VI.—University of Königsberg.

1	Botanical garden	Ry.	2100	0	0
2	Medical establishment		2300	0	0
3	Chirurgic ditto		2455	0	0
4	Theological seminary		440	0	0
5	Philologic ditto		400	0	0
6	Pedagogic ditto		1060	0	0
7	Library		3590	0	0
8	Anatomy		1180	0	0
9	Observatory		1570	0	0
10	Zoological museum		1000	0	0
11	University widow and orphan institution		1000	0	0
12	Cabinet of physical apparatus		158	0	0
13	Establishment for sacred music		164	0	0
14	Ditto for singing		100	0	0
15	Collection of amber and other minerals		100	0	0
16	Polish seminary		50	0	0
17	Medical-polyclinic institution		200	0	0
18	Cabinet of ancient coins		50	0	0
19	Academic collection of arts		112	0	0
20	Midwife-assistant establishment		220	0	0
	(@ 6 Ry. 25 sgr., L.2670. 11. 9d.)				18,249 0 0
	(At the exchange of 6 Ry. 25 sgr., L.22,962. 6s. 6d.	Ry.			156,912 0 8

There are also, unconnected with the universities, theological academies for the Catholics, Lutherans, and Moravians, where they receive the instruction necessary to qualify them for the duties of their functions. Besides these, there are useful establishments for pupils in medicine, surgery, midwifery, the veterinary and military professions, rural economy, and for teaching the deaf and dumb, and the blind.

The collections of natural history, the philosophical and astronomical apparatus, and the public libraries, are upon a very liberal footing, and at the service of any individual who wishes to avail himself of their assistance. The libraries of Berlin thus open to general use contain more than 300,000 volumes, those of Breslau more than 100,000, that of Halle more than 50,000, and in the other cities large collections are generally to be found.

The freedom of the press has of late been somewhat restrained, particularly as relates to fugitive and periodical publications of the smaller class. All books must undergo censorship previous to publication; but works of science are allowed to pass with scarcely any inspection, and there is no restriction on bringing into Prussia any works published in any of the other states of Germany. The universities have an unlimited right of printing without a previous inspection. In the year 1819 the newspapers were, sixty-two government weekly papers, which contained little but domestic intelligence and advertisements; fifteen political papers written by individuals, but with much reserve; and one literary journal.

A savings bank was established in Berlin in 1818. It allows four and a half per cent. on every deposit from a crown upwards. Its capital has increased rapidly, and in 1824 amounted to 685,742 crowns.

The practice of insuring against fire has now become very general, and the property insured in the province of Brandenburg alone in 1824 amounted to 37,854,875 crowns.

Currency. The currency of Prussia consists of metallic and paper money, but the former is so much greater in amount, that the latter suffers no depreciation. The metallic money is estimated to amount to 30,000,000 reichs-thalern. The paper money, including that issued by a privileged com-

Pruym || Prynne.

pany, does not amount to more than 5,000,000, and, by means of a sinking fund, is gradually diminishing, and will soon be extinct. The money is coined in Berlin, Breslau, and Dusseldorf. The gold coins are double, single, and half Frederick William d'ors, valued at 10 d., 5 d. and $2\frac{1}{2}$ d. reichs-thalern. The silver coins are the thaler, the half thaler, and the third, sixth, and twelfth of the thaler. The copper and mixed metal coins are groschen, sechser, drier, and pfenninge. In the old provinces accounts are kept in dollars (thalern), groschen, and pfenningen. Twelve pfenningen make a grosch, and twenty-four groschen a dollar. The value of the dollar in exchange with London varies from three shillings to three shillings and twopence. In the provinces the accounts are kept in various denominations of money, but they are easily reduced into florins or gulden, three of which are equal to two dollars, and the value of which in exchange with London is about two shillings.

The legal long measure of Prussia is the Berlin ell of two feet, which contains $25\frac{3}{8}$ths Rhenish inches, or 296 French lines. In the distant provinces a local measure of length prevails, which differs in each. The Prussian mile is 23,685 feet, or nearly the same as the German geographical mile, or one fifteenth of a degree of latitude, being somewhat less than four and a half English miles. The land measure is the Magdeburg morgen of 100 roods, each rood of twelve feet; and the foot is about one seventh longer than the English; thus the morgen is nearly two thirds of an English acre. The dry measure is the Berlin scheffel of $2758\frac{20}{21}$ Parisian cubic inches, or nearly one bushel, one peck, and one gallon, English measure. The liquid measures are more various than any other, and differ in every province; but as they are all legally reducible to Berlin measure, we give that only, viz. an oxhoft is six eimer, an eimer two ankers, an anker thirty-two quarts, the quart two nöseln. The quart contains fifty-eight Parisian cubic inches, or nearly one ninth less than the English quart. The weights of commerce are the shipslast, containing twelve shipspounds; the shipspound contains 280 common pounds; the centner, of 110 pounds, is divided into light and heavy stones, having ten of the former and five of the latter; the pound is divided into two marks, the mark into sixteen loth, the loth into four quentchen, and the quentchen into four pfenningen.

Prytanes || Psalmanazar.

PRUYM, a city of Prussia, of the province of the Lower Rhine, and government of Trêves. It is the capital of a circle of the same name, which extends over 398 square miles, and comprehends three towns and 156 villages, with 23,500 inhabitants. It was once the capital of a principality, now mediatized, and contains 380 houses, with 2080 inhabitants.

PRYNNE, William, an English lawyer, distinguished in the civil commotions under Charles I., was born at Swainswick, in Somersetshire, in 1600. His *Histriomastix*, written against stage-plays in 1632, contained some reflections which offended the court, and he was in consequence sentenced by the Star-chamber to pay a fine of L.5000, to stand in the pillory, to lose his ears, and to suffer perpetual imprisonment. During his confinement he wrote several more books, particularly one entitled News from Ipswich, in 1637, which, reflecting severely on the bishops, subjected him to another sentence by the Star-chamber, which adjudged him to pay another fine of L.5000, to lose the remainder of his ears in the pillory, to be branded on both cheeks with S. L. for seditious libeller, and to be perpetually imprisoned in Caernarvon Castle. But nothing except cutting off his hands could have prevented Prynne from writing. He continued his favourite employment still; and being set at liberty by the House of Commons in 1640, he entered London in a kind of triumph, was elected member of parliament for Newport in Cornwall, opposed the bishops with great vigour, and was the chief manager of Archbishop Laud's trial. In the long parliament he was zealous in the Presbyterian cause; but when the Independents gained the ascendency he opposed them warmly, and promoted an agreement with the king. When the army expurgated the house and refused him entrance, he became a bitter enemy to them and their leader Cromwell, whom he attacked with so much severity that he was again imprisoned; but he pleaded the liberty of the subject so successfully that he was enlarged, and began to write more controversial books. Being restored to his seat with the other secluded members after Cromwell's death, he assisted in promoting the Restoration, and was appointed keeper of the Records of the Tower; a place excellently well calculated for him, and where he rendered himself very useful by the collections he published from them. He presented forty volumes of his works, in folio and quarto, to Lincoln's-Inn library, of which society he was a member. His principal works are, Records of the Tower, in three volumes folio; and his Parliamentary Writs, in four volumes quarto. The former is one of the rarest works in the whole department of English history. He died in the year 1669, and was buried under the chapel of Lincoln's-Inn.

PRYTANES, in Grecian antiquity, were the presidents of the senate, whose authority consisted chiefly in assembling the senate, which, for the most part, was done once every day. The senate consisted of five hundred, fifty senators being elected out of each tribe; after which, lots were cast to determine in what order the senators of each tribe should preside, which they did by turns, and during their presidentship were called *prytanes*. However, all the fifty prytanes of the tribes did not govern at once, but one at a time, namely, for seven days; and after thirty-five days another tribe came into play, and presided for other five weeks; and so of the rest.

PRZRMYSL, a city of the Austrian kingdom of Galicia, the capital of a circle of the same name, which extends over 2178 square miles. It comprehends five cities, twelve market-towns, and 232 villages, with 238,500 inhabitants, of whom about 16,000 are Jews. The city is fortified, and defended by a lofty castle. It is the see of a bishop, and has a cathedral and fourteen other churches, 760 houses, and 6980 inhabitants, none of them very wealthy. Long. 22. 39. E. Lat. 49. 46. 30. N.

PSALM, a divine song or hymn, but chiefly appropriated to the Psalms of David, a canonical book of the Old Testament. Most of the psalms have a particular title, signifying either the name of the author, the person who was to set it to music or sing it, the instrument which was to be employed, or the subject and occasion of the canticle. Some have imagined that David was the sole author of the Book of Psalms; but the titles of many of them prove the contrary, as Psalm xc., which appears to have been written by Moses. Many of the psalms are inscribed with the names Korah, Jeduthun, and others, from the persons who were to sing them.

PSALMANAZAR, George, the fictitious name of a pretended Formosan, a person of learning and ingenuity. Born in France, he was educated in a free school, and afterwards in a college of Jesuits, in an archiepiscopal city, the name of which, as likewise those of his birth-place and his parents, are unknown. Upon leaving the college he was recommended as a tutor to a young gentleman, but soon fell into a mean and rambling life, which involved him in disappointments and misfortunes. His first pretence was that of being a sufferer for religion. He procured a certificate that he was of Irish extraction, that he had left that country for the sake of the Catholic faith, and was going on a pilgrimage to Rome. But being unable to purchase a pilgrim's garb, and observing one in a chapel, dedicated to a miraculous saint, which had been set up as a monument of

Psalmist ‖ Psalmody.

gratitude by some wandering pilgrims, he contrived to take away both the staff and the cloak; and, thus accoutred, he begged his way in fluent Latin, accosting only clergymen or persons of figure, whom he found so generous and credulous that, before he had gone twenty miles, he might easily have saved money, and put himself in a much better dress. As soon as he had got what he thought sufficient, however, he begged no more, but viewed everything worth seeing, and then retired to some inn, where he spent his money as freely as he had obtained it. Having heard the Jesuits speak much of China and Japan, he started the wild scheme, when he was in Germany, of passing for a native of the island of Formosa; and what he wanted in knowledge he supplied by a pregnant invention. He formed a new character and language on grammatical principles, which, like other oriental languages, he wrote from right to left with great readiness; and he planned a new religion, and a division of the year into twenty months, with other novelties, in order to give credit to his pretensions. He now assumed the character of a Japanese convert to Christianity, travelling for instruction, with an appearance of greater wretchedness than even that of common beggars. He then entered as a soldier in the Dutch service; but, being still desirous of passing for a Japanese, he altered his plan to that of being an unconverted heathen; and at Sluys, Brigadier Lauder, a Scotch colonel, introduced him to the chaplain, who, with the view of recommending himself to the bishop of London, resolved to carry him over to England. At Rotterdam, some persons having put shrewd questions to him, that carried an air of scepticism, he took one more whimsical step, which was to live upon raw flesh, roots, and herbs, thinking that such strange food would remove all scruples. The bishop of London patronized him with credulous humanity; and Psalmanazar found a large circle of friends, who extolled him as a prodigy. Yet there were some who entertained a just opinion of him, particularly Dr Halley, Dr Mead, and Dr Woodward; but their endeavours to expose him as a cheat only made others think the better of him, especially as these gentlemen were supposed to be unfriendly to revelation. In this instance at least, easiness of belief was no great evidence of penetration. He was employed to translate the church catechism into the Formosan language, which was examined, approved, and laid up as a valuable manuscript; and the author, after writing his well-known History of Formosa, was rewarded and sent to Oxford to study what he liked, whilst his patrons and opponents were learnedly disputing at London on the merits of his work. The learned members of the university were no better agreed in their opinions than the savans of London; but at length the sceptics triumphed. Some absurdities were discovered in his history, of such a nature as to discredit the whole narration, and saved him the trouble of an open declaration of his imposture, which, however, he owned at length to his private friends. For the remainder of his life, his learning and ingenuity enabled him to procure a comfortable support by his pen; and he was concerned in several works of credit, particularly The Universal History. He lived irreproachably for many years, and died some time in 1763.

PSALMIST, in the church of Rome, is one of the lesser ecclesiastical orders, being the same with what amongst us is called *clerk*, *precentor*, or *singer*.

PSALMODY, from the Greek, ψαλμος, the art or act of singing psalms. (See PSALM.) The earliest music of the Psalms is not now known. The modern Jewish psalmody is by no means the same in all their synagogues in different countries. Psalms were sung by the primitive Christians, but there are no data to show the precise nature of the melodies. St Augustin (lib. x. Confess. cap. 33) says, "De Alexandrino Episcopo Athanasio sæpe mihi dictum commemini, qui tum modico flexu vocis faciebat sonare lectorem psalmi, ut pronuncianti vicinior esset quam canenti." St Athanasius was made bishop of Alexandria in 326. Of the Ambrosian and Gregorian chants of the fourth and sixth centuries, time and change seem to have spared little more than the tonalities. In Roman Catholic church services the psalmody varies according to the particular occasion; and so also in some Protestant churches. Many of the psalm-tunes now in general use in Protestant churches were composed in the time of Luther, or not long afterwards, for the Protestant congregations which then began to spread over the European continent. Others of these tunes are the productions of various Protestant musicians in later times. Amongst the authors of these more recent tunes, we find the names of some of the Bachs, of Handel, and several other eminent German composers. Psalm-tunes are for voices only, or for voices accompanied by the organ, or for voices accompanied by different instruments; others for a single voice alone, or accompanied, and so on.

Psalter ‖ Pseudonymous.

PSALTER, the same with the book of Psalms. Amongst the religious in the Catholic countries, the term *psalter* is also given to a large chaplet or rosary, consisting of a hundred and fifty beads, according to the number of psalms in the psalter.

PSALTERIUM, Greek ψαλτηριον, formerly called *magadis*, according to Athenæus, an ancient musical instrument, which some writers assert to have been the same as the ancient Hebrew *nebel*. The more modern psaltery being no longer in use, it is unnecessary to describe it.

PSAMMETICUS, or PSAMMITICHUS, a renowned conqueror, who, having subdued eleven petty kings of Egypt, became the founder of the kingdom of Egypt, about 670 before Christ. He is memorable, likewise, for taking the city of Azot, after a siege of twenty-nine years, and for discovering the sources of the river Nile.

PSATYRIANS, a sect of Arians, who, in the council of Antioch, held in the year 360, maintained that the Son was not like the Father as to will; that he was taken from nothing, or made out of nothing; and that in God, generation was not to be distinguished from creation.

PSELLUS, MICHAEL, a learned Christian of the eleventh century, was, by birth, a Constantinopolitan of consular rank, and flourished under the Emperor Constantine Monomachus. His genius and industry raised him far above the level of his contemporaries; and the celebrated historian, Anna Comnena, speaks of him as one who had been more indebted for his attainments to his own excellent talents than to the instructions of his preceptors; adding, that having made himself master of all the wisdom of the Greeks and the Chaldæans, he was justly esteemed the most learned man of the age. Thus furnished, he became the chief instructor of the Constantinopolitan youth. He was at the same time the companion and the preceptor of the emperor, who became so captivated by the studies and amusements in which Psellus engaged him, that, according to Zonaras, he neglected the concerns of the empire. The Byzantine historians complain, that the emperor, deluded by the head of the philosophers, the title with which Psellus was honoured, lost the world. Towards the close of his life, Psellus, meeting with some disappointment, retired into a monastery, and soon afterwards died; but the time of his death is uncertain. His works, which have been much celebrated, are, Commentaries upon Aristotle's Logic and Physics; a Compendium of Questions and Answers; and an explanation of the Chaldaic Oracles. The two latter works prove him to have been conversant, not only with Grecian, but with oriental philosophy.

PSEUDO, from ψευδος, a Greek term, used in the composition of many works to denote *false* or *spurious*.

PSEUDONYMOUS, amongst critics, is an author who publishes a book under a false or feigned name; as *cryp-*

Psylli || Publius Syrus.

tonymous is given to him who publishes one under a disguised name, and *anonymous* to him who publishes without any name at all.

PSYLLI, a people in the south of Cyrenaica, so called from Psyllus, their king, and who were almost all overwhelmed by sand. They had something in their bodies fatal to serpents, and their very savour proved a charm against them.

PTOLEMAIS, in *Ancient Geography*, the port of Arsinoë, situated on the western bank of the Nile, which concurs to form the island called *Nomos Heracleotes*, to the south of the vertex of the Delta.

PTOLEMAIS, the largest and most considerable town of the Thebais, or Upper Egypt, and nothing short of Memphis. It was situated on the western side of the Nile, almost opposite to Coptos. This town was built by Ptolemy Philadelphus.

PTOLMEY SOTER, or *Lagus*, king of Egypt, a renowned warrior and an excellent prince. He established an academy at Alexandria, and was himself a man of letters. He died at the age of ninety-two, 284 years before Christ.

PTOLEMY *Philadelphus*, his second son, succeeded him, to the exclusion of Ptolemy Ceraunus. He was renowned as a conqueror, but more revered for his great virtues and political abilities. He established and augmented the famous library of Alexandria, which had been begun by his father. He also greatly increased the commerce of Egypt, and granted considerable privileges to the Jews, from whom he obtained a copy of the Old Testament, which he caused to be translated into Greek, and deposited in his library. This is supposed to have been the version denominated that of the *Septuagint*. He died at the age of sixty-four, 246 years before Christ.

PTOLMEY *Ceraunus*, the elder brother of the preceding, fled to Seleucus king of Macedonia, who received him hospitably; in return for which Ceraunus assassinated him, and usurped his crown. He then invited Arsinoë, the widow and the sister of the murdered king, to share with him the government; but as soon as he got her in his power, he put her and her children to death. He was at length defeated, killed, and torn limb from limb, by the Gauls, 279 years before Christ.

PTOLMEY, *Claudius*, a celebrated mathematician and astrologer, was born at Pelusium in Egypt. He flourished at Alexandria in the second century, under the reigns of Hadrian and Marcus Aurelius, about the 138th year of the Christian era. There are still extant his Geography, and several learned works on astronomy, the principal of which are, 1. The Almagest; 2. *De Judiciis Astrologicis;* 3. *Planisphærium*. His system of the world was for many years adopted by philosophers and astronomers; but the learned have long rejected it for the system of Copernicus.

PTYALISM, in *Medicine*, a salivation, or frequent and copious discharge of saliva. The word is Greek, being formed from the verb πτυω, *to spit*.

PUBERTY denotes the age at which the person is capable of procreating or begetting children.

PUBERTY, in *Law*, is fixed at the age of twelve in females and fourteen in males; after which they are reckoned fit for marriage. But as to crimes and punishments, the age of puberty is fixed at fourteen in both sexes.

PUBLIUS SYRUS, a celebrated writer of mimes, that is, farces in the language of the common people, flourished at Rome about B. C. 42. He was of Syrian extraction, as his name implies, and was brought to Rome as a slave; but his talents having excited the admiration of his master, he received his freedom. His farces were much admired, and Julius Cæsar is said to have considered them as superior even to those of Laberius. He interspersed them with moral sentences, many of which have been preserved by later writers. St Jerome states that a collection of these moral sentences was made, and that the Romans employed them as a school-book. They have been again collected from various sources, and published several times, along with Seneca or Phædrus; and they have also been published separately. The best edition is that of J. C. Orelli, Leipzig, 1822, or that of C. Zell, Stuttgard, 1829.

Pubna || Puffendorf.

PUBNA, a town of Hindustan, in the province of Bengal, sixty-three miles east from Moorshedabad. Long. 89. 12. E. Lat. 24. N.

PUCHMARY, a town of Northern Hindustan, in the province of Kemaon, situated at the top of a very steep pass in the mountain, in the neighbourhood of which is a cave containing an image of Maha Deo, and his wife Bowanee, to which pilgrims pay their devotions. A perpendicular cliff is also pointed out here, from which the Hindus precipitate themselves as an offering to their idols. Lat. not ascertained.

PUCKHOLI, the capital of a mountainous district of Hindustan, thought to be the Peucelaotis of the Greeks. It was besieged by the army of Alexander, and now belongs to an Afghan chief. Long. 72. 8. E. Lat. 33. 46. N. The district is mountainous, and is situated on the eastern side of the river Indus, about the thirty-fourth degree of north latitude. The climate here is cold, with frequent falls of snow, even in the plains; and it produces all the grains and fruits of Europe. The inhabitants are a rude and savage race, amongst whom there is no security for either life or property.

PUCOULOE, a town of Hindustan, in the province of Bengal, and district of Dacca. Long. 89. 55. E. Lat. 24. 8. N.

PUDDAR, a river of Hindustan, which rises in the province of Ajmeer, and empties itself into the Gulf of Cutch, thirty miles south-west of Janagur.

PUDUCOTTA, a town of Hindustan, in the Southern Carnatic, and district of Tanjore. It was formerly the capital of Tondiman, the hereditary polygar or landholder of a considerable district. It is thirty-two miles south-south-west from Tanjore. Long. 78. 50. E. Lat. 16. 20. N.

PUEGOS, or SIQUIOR, one of the Philippine Islands. It is small, but abounds in inhabitants, who are brave and warlike. It is 50 miles north from the western part of Mindanao.

PUDSEY, a township of the west riding of Yorkshire, in the wapentake of Morley and parish of Calverly, 197 miles from London. It has an establishment settled in 1748, by a colony of Moravians from Germany, who built a village called Fulneck, from the name of the place whence they had emigrated. The large building appropriated to their use has a chapel, a dining-room, and separate divisions for the two sexes till marriage, which is said to be determined by lot. They pursue various manufacturing branches of industry. The population of the township amounted in in 1811 to 4697, in 1821 to 6229, and in 1831 to 7460.

PUERTO-REAL, a city of Spain, in Andalusia, in the province or portedo of Cadiz. It stands on the bay which takes its name from that city, and has a canal communicating with it. It is near the mouth of the river Guadalete, and is defended towards the water by some powerful batteries. It has a tolerable haven, in which there are establishments for building ships. The streets are wide and clean, and many of the houses magnificent. It contains five churches, three monasteries, a naval hospital, 1050 houses, and between 10,000 and 11,000 inhabitants. Near to it are those great masses of salt which are produced by natural evaporation from sea-water, and with which hundreds of ships are yearly loaded to all parts of the world.

PUFFENDORF, SAMUEL DE, a very distinguished jurist and historian, was born in 1631, at Fleh, a little village in Misnia, a province in Upper Saxony, being the son of Elias Puffendorf, minister of that place. After having made great progress in the sciences at Leipzig, he turned his thoughts to the study of public law; which in Germany consists of the knowledge of the rights of the empire over the

Pularim ‖ Pulawy.

princes and states of which it is composed, and those of the princes and states with respect to each other. But though he used his utmost efforts to distinguish himself, he despised those pompous titles which are so much sought after at universities, and never would take the degree of doctor. He accepted the place of governor to the son of Coyet, a Swedish nobleman, who was then ambassador from Sweden to the court of Denmark. For this purpose he went to Copenhagen, but did not continue long at his ease there; for the war being some time afterwards renewed between Denmark and Sweden, he was seized, along with the whole family of the ambassador. During his confinement, which lasted eight months, as he had no books, and was not allowed to see any person, he amused himself by meditating on what he had read in the treatise of Grotius, *De Jure Belli et Pacis*, and the political writings of Hobbes. Out of these he drew up a short system, to which he added some thoughts of his own, and published it at the Hague in 1660, under the title of *Elementa Jurisprudentiæ Universalis*. This recommended him to the elector palatine, who invited him to the university of Heidelberg, where he founded in his favour a professorship of the law of nature and nations, which was the first chair of the kind established in Germany. Puffendorf remained at Heidelberg till 1673, when Charles XI. of Sweden gave him an invitation to become professor of the law of nature and nations at Lunden; a place which the elector palatine reluctantly allowed him to accept. He went thither the same year; and after that time his reputation greatly increased. Some years afterwards, the king of Sweden sent for him to Stockholm, and appointed him historiographer and one of his counsellors. In 1688, the elector of Brandenburg obtained the consent of his Swedish majesty that Puffendorf should come to Berlin in order to write the history of the elector William the Great; and in the year 1694 the elector made him a baron. But he died the same year, of an inflammation in his feet, occasioned by cutting his nails, having already attained his grand climacteric. Of his works, which are numerous, the following are the principal, viz. 1. A Treatise on the Law of Nature and Nations, written in German, of which there is an English translation with Barbeyrac's Notes; 2. An Introduction to the History of the Principal States which at present subsist in Europe, written in German, but also translated into English; 3. The History of Sweden, from Gustavus Adolphus's Expedition into Germany to the Abdication of Queen Christina; 4. The History of Charles Gustavus, in two vols. folio.

PULARIM, or Polaroon, one of the Banda Isles, and the smallest of the whole. The possession of this island was contested between the English East India Company and the Dutch. The English obtained possession of it in 1617, but were repeatedly expelled by the Dutch. In 1665 it was formally delivered up to the English, but in so desolated a state, the whole of the spice-trees having been destroyed, that it was rendered useless for eight years. In 1666 it was re-occupied by the Dutch. Long. 129. 45. E. Lat. 5. 35. N.

PULAWY, a city of Poland, in the province of Lublin, and the circle of that name. It stands on the right bank of the Vistula, over which is a ferry where the roads on both sides are concentrated. It is in a beautiful situation, rising above and overlooking the river. It contains 430 houses, with 3200 inhabitants, who carry on some woollen and other manufactures. It is distinguished by the magnificent palace adjoining to it, belonging, as well as the city and the surrounding district, to the celebrated family of Prince Czartoryski. It is a building of noble construction, having an extensive park laid out in the English style, with elegant drives and walks, and many beautiful trees. In the park is a museum of curiosities, and in the castle a curious and valuable library of 60,000 volumes, and many manuscripts illustrative of the ancient history of Poland. Long. 21. 41. E. Lat. 51. 25. N.

Pullicat ‖ Pulo.

PULLICAT, a town of Hindustan, on the sea-coast of the Carnatic, situated on the borders of a salt-water lake, thirty-three miles in length by eleven in breadth, containing several islands, and communicating with the sea. This lake owes its existence to the sea breaking through a low sandy beach, and overflowing the lands within. The Dutch first settled here in 1609, which, after the loss of Negapatam, became the seat of their government on the Coromandel coast. The inhabitants are principally manufacturers and fishermen, who manufactured the handkerchiefs that took their name from this town. In 1795, when war commenced between Great Britain and Holland, the East India Company's troops took possession of this place, which is now comprehended in the northern division of the Arcot collectorship. It is twenty-five miles north of Madras. Long. 80. 25. E. Lat. 13. 26. N.

PULMARY, a town of Hindustan, in the nizam's dominions, in the province of Aurungabad. It is thirty miles west of Jalnapoor. Long. 76. 3. E. Lat. 19. 59. N.

PULO, in the Eastern languages, means *small*, and this epithet is accordingly applied to numerous islands in the Eastern Seas, the chief of which are comprised in the following list.

Pulo Akat, a small island in the Eastern Seas, near the north-east coast of Ceram, in long. 131. 3. E. lat. 3. 6. S. Pulo Ampal, Pulo Anam, two small islands near the western coast of Sumatra, the first in long. 99. 29. E. lat. 0. 44. S., the second in long. 99. 27. E. lat. 0. 40. S. Pulo Anna, a small island in the Pacific Ocean, in long. 131. 46. E. lat. 4. 38. N. Pulo Aru, in the Straits of Malacca, in long. 100. 24. E. lat. 2. 57. N. Pulo Ay, a small island in the Eastern Seas, to the westward of the Great Banda. It is rich in the production of spices, the soil being particularly favourable to the growth of the nutmeg tree. Pulo Ayer, near the west coast of Sumatra. Long. 100. 12. E. Lat. 1. 11. S. Pulo Babee, in the Straits of Sunda. Long. 106. 10. E. Lat. 5. 45. S. Pulo Babi, near the north coast of the island of Nias, where there is abundance of buffaloes and hogs. Pulo Bally, divided from the island of Bachian by a channel five miles wide. It is about two miles round, and has abundance of wood and fresh water. Pulo Baniack, about twenty-five miles in circumference, off the west coast of Sumatra, between the second and third degrees of north latitude. Pulo Batu, an island about forty miles off the western coast of Sumatra, forty miles long and twelve broad. Long. 97. 56. E. Lat. 0. 20. N. Pulo Bava, near the south coast of Nias. Long. 97. 18. E. Lat. 0. 52. N. Pulo Bicie, an elevated island in the Straits of Sunda. Pulo Bintango, near the west coast of Sumatra. Long. 99. 47. E. Lat. 0. 58. S. Pulo Brasse, of a triangular form, about ten miles in circumference, near the north-west coast of Sumatra. Long. 95. 30. E. Lat. 5. 39. N. Pulo Bringen, near the west coast of Sumatra. Long. 100. 21. E. Lat. 1. 58. S. Pulo Cannibaz, on the southern coast of Java, from which it is separated by a narrow strait. It is twenty miles in length by six in average breadth. Long. 109. 25. E. Lat. 7. 50. S. Pulo Casse, in the Eastern Seas, near the west coast of Sumatra. Long. 99. 28. E. Lat. 0. 20. S. Pulo Condore Isles, a cluster of small islands in the Eastern Seas, situated off the south coast of Cambodia. The principal island is twelve miles in length and three in breadth. The inhabitants are mostly refugees from Cochin China, and can supply ships that touch here, with some refreshments. Their flat faces and long and small eyes denote a Chinese origin. The English had a settlement here in 1704. Pulo Dammer, in the Eastern Seas, about thirty miles in circumference, near the south coast of Gilolo. Long. 128. 22. E. Lat. 0. 58. S. Pulo Datte, in the Eastern Seas, near the

Pulo.

west coast of Borneo. Long. 108. 59. E. Lat. 0. 8. N. Pulo Doa, near the west coast of Sumatra. Long. 97. 33. E. Lat. 1. 18. N. Pulo Docan, Long. 105. 39. E. Lat. 1. 2. S. Pulo Dua, near the west coast of Sumatra. Long. 97. E. Lat. 2. 46. N. Pulo Een, on the north coast of Waygiou. Long. 130. 37. E. Lat. 0. 12. N. Pulo Ely, near the west coast of Sumatra. Long. 98. 11. E. Lat. 1. 6. N. Pulo Gasseb, near the south-east coast of the island of Ceram. Long. 131. 13. E. Lat. 3. 29. S. Pulo Gasses, near the east coast of the island of Oby. Long. 128. 20. E. Lat. 1. 37. S. Pulo Goere, near the north coast of Sumatra. Long. 97. 42. E. Lat. 4. 42. N. Pulo Gontei, near the coast of Sumatra. Long. 95. 23. E. Lat. 5. 15. N. Pulo Gunton, in the Straits of Malacca. Long. 101. 38. E. Lat. 1. 22. N. Pulo Jarejah, in the Straits of Malacca, three miles long, with abundance of wood and water. Pulo Kaka, off the south-west of the island of Celebes, about fifteen miles long. Pulo Kapini, or Iron Wood Island, between the west coast of Sumatra and Pulo Batu. Pulo Lalang, in the Straits of Malacca, about fifty miles in circumference. Long. 100. 9. E. Lat. 2. 25. N. Pulo Laut, situated at the south entrance of the Straits of Macassar, near the south-east coast of the island of Borneo, about a hundred miles in circumference. It is but thinly inhabited, and produces chiefly rice. The channel which separates it from Borneo is about two miles wide and eight fathoms deep all the way, and is a good harbour for shipping. Long. 116. 24. E. Lat. 3. 45. S. Pulo Laut, Little, a group of small islands, eighteen miles south of Pulo Laut. Long. 115. 55. E. Lat. 4. 54. S. Pulo Lawn, Long. 128. 48. E. Lat. 1. 33. S. Pulo Leat, Long. 107. 5. E. Lat. 2. 51. S. Pulo Majo, near the north coast of Cumbava. Long. 117. 20. E. Lat. 8. 11. S. Pulo Malora, near the north coast of Sumatra. Long. 95. 39. E. Lat. 5. 24. N. Pulo Mariore, in the Pacific Ocean. Long. 131. 57. E. Lat. 4. 17. N. Pulo Marra, near the west coast of Sumatra. Long. 99. 48. E. Lat. 1. 2. S. Pulo Mega, a small uninhabited island surrounded by a coral reef. Latitude not ascertained. Pulo Moar, near the east coast of Gilolo. Long. 128. 58. E. Lat. 0. 6. N. Pulo Nako-Nako, a cluster of small islands near the western coast of the island of Nias. Large quantities of cocoa-nut oil are exported. Pulo Nancy, near the north coast of Sumatra, about twenty miles in circumference. Long. 95. 21. E. Lat. 5. 18. N. Pulo Niamo, near the west coast of Sumatra. Long. 99. 45. E. Lat. 1. 8. S. Pulo Nye, near the west coast of the island of Poggy. Long. 99. 32. E. Lat. 2. 48. S. Pulo Pahang, near the coast of Malacca, about five miles from the town of Pahang. Pulo Panca, near the west coast of Sumatra. Long. 98. 35. E. Lat. 0. 18. N. Pulo Panjang, in the Eastern Seas, on the north coast of the island of Java, in the bay of Bantam. Long. 104. 55. E. Lat. 1. 3. S. Pulo Penneu, near the west coast of Sumatra. Long. 100. 2. E. Lat. 1. 28. S. Pulo Pinang, see PRINCE OF WALES ISLAND. Pulo Pisang, Long. 128. 49. E. Lat. 1. 22. S. Another of this name, one of the Banda Islands, two miles north-east of Banda Neira. Pulo Prampton, one of the Banda Islands. Long. 130. 38. E. Lat. 4. 2. S. Pulo Ron, near the south-east coast of Gilolo. Long. 128. 30. E. Lat. 0. 48. S. Pulo Rondo, a cluster of small islands to the north of Sumatra. Long. 95. 22. E. Lat. 4. 45. N. Pulo Roopat, an island in the Straits of Malacca, 120 miles in circumference, separated by a narrow channel from the island of Sumatra. Long. 101. 9. E. Lat. 1. 58. N. Pulo Rou, near the coast of Malacca. Long. 102. 12. E. Lat. 7. N. Pulo Sabadda, near the west coast of Sumatra. Long. 99. 53. E. Lat. 1. 3. S. Pulo Sabuda, about thirty miles west from New Guinea. Long. 131. 48. E. Lat. 2. 35. S. Pulo Salanama, in the Straits of Malacca, near the north coast of the island of Sumatra. Long. 98. 51. E. Lat. 3. 27. N. Pulo Sallier, in the Eastern Seas. Long. 105. 56. E. Lat. 5. 50. S. Pulo Sambolong, a cluster of islands at the entrance of the river Pera, on the coast of Malacca. Pulo Sanding or Sandiang, two small islands near the south-eastern extremity of the Nassau or Poggy Isles, in which group they are sometimes included. Pulo See Booro, near the north coast of the island of Pera. Long. 99. 9. E. Lat. 1. 52. S. Pulo See Geere, near the north coast of the island of Pera. Long. 99. 10. E. Lat. 1. 55. S. Pulo Seyer, a cluster of small islands. Long. 97. 15. E. Lat. 8. 40. N. Pulo Sonaro, near the west coast of Sumatra. Long. 99. 42. E. Lat. 0. 53. S. Pulo Suanjee, one of the Banda Islands. Long. 130. 20. E. Lat. 4. 6. S. Pulo Tamong, near the west coast of Sumatra. Long. 98. 24. E. Lat. 0. 27. N. Pulo Taya, Long. 104. 57. E. Lat. 0. 42. S. Pulo Teega, near the west coast of Sumatra. Long. 99. 40. E. Lat. 0. 52. S. Pulo Tellore, near the west coast of Sumatra. Long. 100. 15. E. Lat. 1. 42. S. Pulo Timoan, a mountainous and woody island, inhabited by Malays. It produces in abundance rice, and the cabbage and the cocoa-nut trees. Long. 104. 25. E. Lat. 3. N. Pulo Timpalis, in the Straits of Malacca, near the north-east coast of Sumatra. Long. 94. 45. E. Lat. 4. 27. N. Pulo Toti, between the islands of Borneo and Sumatra, in lat. 0. 53. S. Pulo Troosan, near the west coast of Sumatra. Long. 99. 58. E. Lat. 1. 6. S. Pulo Tullong, in the Straits of Malacca. Long. 100. 33. E. Lat. 4. 27. N. Pulo Varella, in the Straits of Malacca, about twenty miles off the north-east coast of Sumatra. Long. 99. 36. E. Lat. 3. 47. N. Pulo Way, one of the Spice Islands, in the Eastern Seas, about nine miles west of Gorong Apee. Long. 130. 26. E. Lat. 4. 9. S. Pulo Way, an island about thirty miles in circumference, near the north coast of Sumatra. Long. 95. 33. E. Lat. 5. 33. N.

Pulpit ‖ Pulse.

PULPIT, an elevated place in a church, from which sermons are delivered. The French give the same name to a reading desk.

PULPITUM, in the Grecian and Roman theatres, was a place where the players performed their parts. It was lower than the scena, and higher than the orchestra, nearly answering to what we call the stage, as distinguished from the pit and the galleries. *Pulpitum* was also a moveable desk or pulpit, from which disputants pronounced their dissertations, and authors recited their works.

PULSE, in the animal economy, denotes the beating or throbbing of the heart and arteries.

No doctrine has been involved in greater difficulties than that of pulses, since, in giving a physiological account of them, physicians have espoused quite opposite sentiments; whilst some doubt whether the pulse is owing to the systole or diastole, as also, whether the motion of the heart and arteries be one and the same for a given instant of time.

With regard to motion, the pulses are reckoned only four; the great and little, the quick and slow. When quickness and greatness are joined together, it becomes violent; and when it is little and slow it is called a weak pulse. Pulses are also said to be frequent and rare, equal and unequal; but these are not the essential affections of motion. Frequency and quickness are often confounded with each other. A pulse is said to be hard or soft, with regard to the artery, according as it is tense, renitent, and hard, or flaccid, soft, and lax; for as the disposition of the arteries contributes greatly to the change of the pulse, it sometimes happens that the pulse in both arms is not alike, which is very common in hemiplexy. To these may be added a convulsive pulse, which does not proceed from the blood, but from the state of the artery, and is known by a tremulous subsultory motion, whilst the artery seems to be drawn upwards. This, in acute fevers, is the sign of death, and is said to be the pulse in dying persons, which is likewise generally unequal and intermitting. A great pulse shows

Pultawa. a more copious afflux of the blood to the heart, and thence into the arteries; a little pulse indicates the contrary.

The pulses of persons differ according to the largeness of the heart and vessels, the quantity and temperies of the blood, the elastic force of the canals, and also with regard to the sex, age, season, air, motion, food, sleep, watchings, and passions of the mind. The pulse is larger and quicker in men than in women; in the bilious and sanguineo-bilious, than in the phlegmatic and melancholic. Those who are lean, with tense fibres and large vessels, have a greater and a stronger pulse than those who are fat, with lax fibres and small vessels; and hence they are much more healthy, robust, and apt for labour. In children the pulse is quick and soft, in adults greater and more violent. In the old it is commonly great, hard, and slow. Labour, motion, and exercise of the body, increase the circulation of the blood, the excretions, and particularly respiration; rest renders the circulation slow and weak. Animated speaking increases the circulation, and consequently renders the pulse large and quick. In watching, the pulse is more evident; in sleep, slower and more languid. After drinking hot things, such as coffee and tea, or hot-bath waters, as well as after meals, the pulse vibrates more quickly. But nothing produces a greater change in the pulse than the affections of the mind. In terror it is unequal, small, and contracted; in joy, frequent and great; in anger, quick and hard; in sadness, slow, small, deep, and weak; and in intense study, languid and weak. With regard to the atmosphere, when, after the predominance of a west or south wind, it comes round to north or east, the pulse is stronger and larger; and also when the quicksilver rises in the barometer. But when the atmosphere is dense, humid, and rainy, with a long south wind, and also where the life is sedentary, the sleep long, and the season autumnal, the pulse is languid and small, and the perspiration decreased. In May it is great, and sometimes violent; in the middle of summer, quick but weak; in the autumn, slow, soft, and weak; in the winter, hard and great. A drastic purge and an emetic render the pulse hard, quick, and weak, with loss of strength; chalybeates and bark render it great and robust, and the complexion lively; volatiles amplify and increase the pulse; acids and nitrous remedies refrigerate the body and appease the pulse; opiates and the like render it small and weak, and decrease the elasticity of the solids; and poisons render it small, contracted, and hard. When the quantity of the blood is too great, bleeding raises the pulse.

PULTAWA, a government of the Russian empire, extending in north latitude from 48. 48. to 51. 4. and in east longitude from 30. 20. to 35. 55., and comprehending 16,236 square miles. It is bounded on the north-west by Tchernigow and a part of Kursk, on the north-east by Slobodsk-Ukraine, on the south-east by Ykaterinoslav, on the south-west by Cherson, and on the west by Kiew. It contains twenty-two cities and towns, and 983 parishes, with 1,933,000 inhabitants. It is generally a plain, with scarcely any elevations, and is drained by the river Dnieper, which passes on its western sides, receives the waters of all the smaller streams, and is navigable to the sea. It is perhaps the best cultivated and the most productive of all the Russian provinces, yielding very good crops of corn, chiefly rye, and also affording more of wheat, barley, oats, and buckwheat, than the domestic consumption requires. The produce of flax, hemp, and tobacco, as well as beans and pease, is abundant. Wine is raised, but not copiously, because, there being no hills to protect the vines from the sharp northerly and easterly winds, they are injured by frost. The steppes cover a part of the province, but they produce excellent grass, and fatten numerous herds of black cattle. There are no mines in the province; but some chalk, limestone, and saltpetre are obtained. There are some manufactures of woollen and of linen cloth of the coarser kinds, and some excellent leather is prepared. The chief manufactured article for exportation is corn brandy, to which purpose the greater portion of the surplus grain is applied. Though the river Dnieper is always navigable, yet the small streams are not so, except for a short time in the spring; and as the roads are heavy, this obstacle opposes the export of the productions, and limits the trade to very narrow bounds. Pultawa ‖ Pumice-stone River.

PULTAWA, a city of Russia, the capital of the government of the same name, as well as of the circle. It is situated on the river Borskla, where the Pultawka falls into that stream. It is the see of a bishop of an extensive diocese, is surrounded with earthen walls, has a cathedral and nine other churches, 1200 houses, and 10,000 inhabitants. It has been rendered celebrated as the place of refuge of Charles XII. of Sweden, after his defeat in 1709. It is 948 miles from St Petersburg. Long. 34. 35. E. Lat. 43. 33. N.

PULTENEY, WILLIAM, the famous opponent of Sir Robert Walpole in parliament, and afterwards Earl of Bath, was descended from one of the most ancient families in the kingdom, and born in the year 1682. Possessing an affluent fortune, he early procured a seat in the House of Commons, and distinguished himself as a warm partisan against Queen Anne's ministry, whose errors he had the sagacity to detect and the eloquence to expose. When George I. came to the throne, Mr Pulteney was made secretary at war, and soon afterwards cofferer to the king's household; but the good understanding between this gentleman and Sir Robert Walpole, who then acted as prime minister, was interrupted in 1725, on a suspicion that Walpole was desirous of extending the limits of prerogative, and of promoting the interests of Hanover, to the prejudice of those of Britain. His opposition to Sir Robert was indeed carried to such indiscriminate lengths, that some persons have been of opinion he often acted against measures beneficial to the public, merely from personal motives. It would be impracticable here to trace his parliamentary conduct. It may suffice to observe in general, that he became so obnoxious to the crown, that in 1731 the king called for the council-book, and with his own hand struck out his name from the list of privy-councillors; a proceeding which only served to inflame his resentment and increase his popularity. He still continued to attack the minister with a severity of eloquence and sarcasm that worsted every antagonist; and Sir Robert was heard to declare, that he dreaded that man's tongue more than another man's sword. At length, in 1741, when Walpole found the place of prime minister no longer tenable, and resigned, amongst other promotions Mr Pulteney resumed his place in the privy-council, and was created Earl of Bath; a title purchased at the expense of that popularity which he afterwards naturally enough affected to contemn. In 1760, towards the close of the war, he published A Letter to two Great Men, recommending proper articles to be insisted on in a treaty of peace; a production which, though the writer was then unknown, was greatly applauded, and went through several impressions. He died in 1764; and, as his only son had died before him, the title became extinct.

PULVERIZATION, the art of pulverizing, or reducing a dry body into a fine powder. This is performed in friable bodies by pounding or beating them in a mortar; but to pulverize malleable ones, other methods must be taken. To pulverize lead or tin, the method is this: Rub a round wooden box all over the inside with chalk; pour a little of the melted metal nimbly into the box; then shut the lid, and shake the box briskly, when the metal will be reduced to powder.

PUMICE-STONE RIVER, a river on the east coast of New Holland, entered by Captain Flinders in 1799, and so called from the quantity of pumice-stone found on its shores. It falls into Glass-house Bay.

PUMP.

Pump.

PUMP, an hydraulic machine for raising water by means of the pressure of the atmosphere.

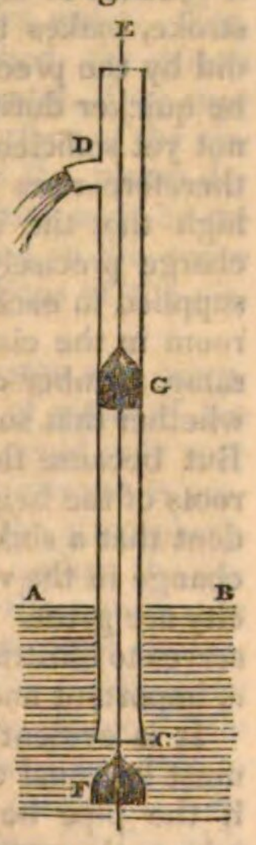
Of the invention of pumps.

It would be interesting to learn the progressive steps by which the ingenuity of man has invented the various methods of raising water. A pump must be considered as the last step of this progress. Common as it is, it is a very abstruse and refined invention. Nothing like it has been found in any of the rude nations, either in the new continent of America, or the islands of the Pacific Ocean. Nay, it was unknown in China at the time of our arrival there by sea, and it is still a rarity everywhere in Asia, in places unfrequented by Europeans. It does not appear to have been known to the Greeks and Romans in early times; and perhaps it came from Alexandria, where physical and mathematical science was much cultivated by the Greek school under the protection of the Ptolemies. The performances of Ctesibius and Hero are spoken of by Pliny and Vitruvius as curious novelties.[1] It is perhaps not difficult to trace the steps by which those mechanicians were led to the invention. The Egyptian wheel was a common machine all over Asia, and is still in use in the remotest parts, and was brought by the Saracens into Spain, where it is still very common under its ancient name *noria*. The Danish missionaries found in a remote village in the kingdom of Siam the immediate offspring of the noria (*Lettres Edifiantes et Curieuses*). It was a wheel turned by an ass, and carrying round, not a string of earthen pots, but a string of wisps of hay, which it drew through a wooden trunk. This rude chain-pump was in frequent use for watering the rice fields. It is highly probable that it is of great antiquity, although we do not recollect its being mentioned by any of the Greek or Roman writers. The Arabs and Indians were nothing less than innovators; and we may suppose with great safety, that what arts we now find among them they possessed in very remote periods. Now the step from this to the pump is but short, though it is nice and refined; and the forcing pump of Ctesibius is the easiest and most natural.

Ctesibius's pumps.

Let AB (fig. 1) be the surface of the water in the well, and D the height where it is to be delivered. Let DC be a long wooden trunk, reaching as deep under water as possible. Let the rope EF be fitted with its knot of hay F. When it is drawn up through the trunk, it will bring up along with it all the water lying between C and A, which will begin to run out by the spout D as soon as the knot gets to G, as far below D as C is below A. All this is very obvious; and it required but little reflection to be assured, that if F was let down again, or pushed down, by a rod instead of a rope, it would again perform the same office. Here is a very simple pump. And if it was ever put in practice, it behoved to show the supporting power of the atmosphere, because the water would not only be lifted by the knot, but would even follow it. The imperfection of this pump behoved to appear at first sight, and to suggest its remedy. By pushing down the knot F, which we shall henceforth call the *piston*, all the force expended in lifting up the water between A and G is thrown away, because it is again let down. A valve G at the bottom would prevent this. But then there must be a passage made for the water by a lateral tube KBD (fig. 2). And if this be also furnished with a valve H, to prevent its losing the water, we have the pump of Ctesibius, as sketched in fig. 2. The valve is the great refinement; but perhaps even this had made its appearance before in the noria. For, in the more perfect kinds of these machines, the pots have a stop or valve in their bottom, which hangs open while the pot descends with its mouth downwards, and then allows it to fill readily in the cistern; whereas, without the valve, it would occasion a double load to the wheel. If we suppose that the valve had made its appearance so early, it is not improbable that the common pump sketched in fig. 3 was as old as that of Ctesibius. In this place we shall first give a short description of the chief varieties of these engines, considering them in their simplest form; and we shall explain, in very general terms, their mode of operation. We shall then give a concise and popular theory of their operation, furnishing principles to direct us in their construction; and we shall conclude with the description of a few peculiarities which may contribute to their improvement or perfection.

Fig. 1.

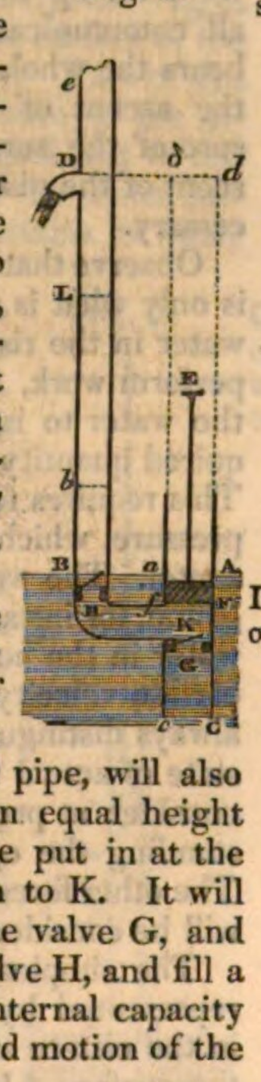


There are but two sorts of pumps which essentially differ; and all the varieties that we see are only modifications of these. One of these original pumps has a solid piston; the other has a piston with a perforation and a valve. We usually call the first a *forcing pump*, and the second a *lifting* or *sucking pump*.

Forcing pump described.

Fig. 2 is a sketch of the forcing pump in its most simple form and situation. It consists of a hollow cylinder AC *ca*, called the *working barrel*, open at both ends, and having a valve G at the bottom opening upwards. This cylinder is filled by a solid piston EF, covered externally with leather or tow, by which means it fits the box of the cylinder exactly, and allows no water to escape by its sides. There is a pipe KHD, which communicates laterally with this cylinder, and has a valve at some convenient place H, as near as possible to its junction with the cylinder. This valve also opens upwards. This pipe, usually called the *rising pipe* or *main*, terminates at the place D, where the water must be delivered.

Fig. 2.



Its mode of operation.

Now suppose this apparatus set into the water, so that the upper end of the cylinder may be under or even with the surface of the water AB; the water will open the valve G, and after filling the barrel and lateral pipe, will also open the valve H, and at last stand at an equal height within and without. Now let the piston be put in at the top of the working barrel, and thrust down to K. It will push the water before it. This will shut the valve G, and the water will make its way through the valve H, and fill a part B*b* of the rising pipe, equal to the internal capacity of the working barrel. When this downward motion of the

[1] In the early Greek writings, it does not appear that the words ἀντλος, ἀντλειν, ἀντλια, &c. were used to express any thing like what we call a pump. In all the passages where these words occur, they either express generally the drawing of water, or, more particularly, the drawing it with a bucket or something similar. Ἀντλος, which is the primitive, is a drain, sink, or receptacle for collecting water, either for use or to get rid of it; hence it came to signify the sink or well of a ship; and ἀντλειν was synonymous with our

Pump. piston ceases, the valve H will fall down by its own weight and shut this passage. Now let the piston be drawn up again. The valve H hinders the water in the rising pipe from returning into the working barrel. But now the valve G is opened by the pressure of the external water, and the water enters and fills the cylinder as the piston rises. When the piston has got to the top, let it be thrust down again. The valve G will again be shut, and the water will be forced through the passage at H, and rise along the main, pushing before it the water already there, and will now have its surface at L. Repeating this operation, the water must at last arrive at D, however remote; and the next stroke would raise it to *e*; so that during the next rise of the piston the water in *e*D will be running off by the spout.

The effect is the same whatever be the position of the working barrel, provided only that it be under water. It may lie horizontally or sloping, or it may be with its mouth and piston rod undermost. It is still the same forcing pump, and operates in the same manner and by the same means, viz. the pressure of the surrounding water.

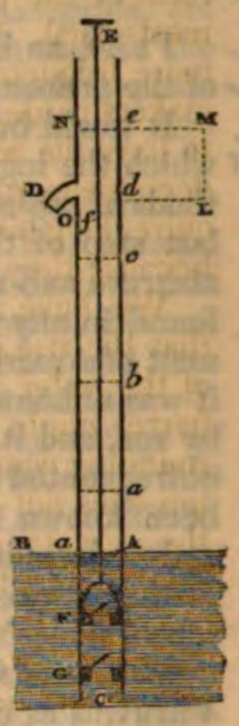
The external force which must be applied to produce this effect is opposed by the pressure exerted by the water on the opposite face of the piston. It is evident, from the common laws of hydrostatics, that this opposing pressure is equal to the weight of a pillar of water having the face of the piston for its base, and the perpendicular height *d*A of the place of delivery above the surface of the water AB in the cistern for its height. The form and dimensions of the rising pipe are indifferent in this respect, because heavy fluids press only in the proportion of their perpendicular height. Observe that it is not *d*F, but *d*A, which measures this pressure, which the moving force must balance and surmount. The whole pressure on the under surface F*f* of the piston is indeed equal to the weight of the pillar *d*F*f*δ; but part of this is balanced by the water AF*f*α. If, indeed, the water does not get into the upper part of the working barrel, this compensation does not obtain. While we draw up the piston, this pressure is removed, because all communication is cut off by the valve H, which now bears the whole pressure of the water in the main. Nay, the ascent of the piston is even assisted by the pressure of the surrounding water. It is only during the descent of the piston, therefore, that the external force is necessary.

Observe that the measure now given of the external force is only what is necessary for *balancing* the pressure of the water in the rising pipe. But in order that the pump may perform work, it must *surmount* this pressure, and cause the water to issue at D with such a velocity that the required quantity of water may be delivered in a given time. This requires force, even although there were no opposing pressure, which would be the case if the main were horizontal. The water fills it, but it is at rest. In order that a gallon, for instance, may be delivered in a second, the whole water in the horizontal main must be put in motion with a certain velocity. This requires force. We must therefore always distinguish between the state of equilibrium and the state of actual working. It is the equilibrium only that we consider at present; and no more is necessary for understanding the operation of the different species of pumps. The other force is of much more intricate investigation, and will be considered by itself.

Lifting pump. The simplest form and situation of the lifting pump is represented by the sketch fig. 3. The pump is immersed in the cistern till both the valve G and piston F are under the surface AB of the surrounding water. By this means the water enters the pump, opening both valves, and finally stands on a level within and without. Pump.

Its mode of operating.

Fig. 3.



Now draw up the piston to the surface A. It must lift up the water which is above it (because the valve in the piston remains shut by its own weight); so that its surface will now be at *a*, A*a* being made equal to αF. In the mean time, the pressure of the surrounding water forces it into the working barrel, through the valve G; and the barrel is now filled with water. Now, let the piston be pushed down again; the valve G immediately shuts by its own weight, and in opposition to the endeavours which the water in the barrel makes to escape this way. This attempt to compress the water in the barrel causes it to open the valve F in the piston; or rather this valve yields to our endeavour to push the piston down through the water in the working barrel. By this means we get the piston to the bottom of the barrel; and it has now above it the whole pillar of water reaching to the height *a*. Drawing up the piston to the surface A a second time must lift this double column along with it, and its surface will now be at *b*. The piston may again be thrust down through the water in the barrel, and again drawn up to the surface, which will raise the water to *c*. Another repetition will raise it to *d*; and it will now show itself at the intended place of delivery. Another repetition will raise it to *e*; and while the piston is now descending to make another stroke, the water in *e d* will be running off through the spout D; and thus a stream will be produced, in some degree continual, but very unequal. This is inconvenient in many cases: thus, in a pump for domestic uses, such a hobbling stream would make it very troublesome to fill a bucket. It is therefore usual to terminate the main by a cistern LMNO, and to make the spout small. By this means the water brought up by the successive strokes of the piston rises to such a height in this cistern as to produce an efflux by the spout nearly equable. The smaller we make the spout D the more equable will be the stream; for when the piston brings up more water than can be discharged during its descent, some of it remains in the cistern. This, added to the supply of next stroke, makes the water rise higher in the cistern than it did by the preceding stroke. This will cause the efflux to be quicker during the descent of the piston, but perhaps not yet sufficiently quick to discharge the whole supply. It therefore rises higher next stroke; and at last it rises so high that the increased velocity of efflux makes the discharge precisely balance the supply. Now, the quantity supplied in each stroke is the same, and occupies the same room in the cistern at top: and the surface will sink the same number of inches during the descent of the piston, whether that surface has been high or low at the beginning. But because the velocities of the efflux are as the square roots of the heights of the water above the spout, it is evident that a sink of two or three inches will make a smaller change in the velocity of efflux when this height and velocity are great. This seems but a trifling observation; but it serves to illustrate a thing to be considered afterwards, which is important and abstruse, but perfectly similar to this.

It is evident that the force necessary for this operation must be equal to the weight of the pillar of water *d* A α D, if the pipe be perpendicular. If the pump be standing aslope, the pressure which is to be balanced is still equal to

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expression "to bale the boat." (*Odyssey*, O. 476, M. 411; Euripides, *Hecuba*, 1025.) Ἀντλιον is the *vessel* or *bucket* with which water is drawn. Ἀντλια is the service, which was generally a punishment, of drawing water. Ἀντλειν means to draw water with a bucket; hence the force of Aristotle's expression (*Œcon.* i.) τῳ γαρ ἠθμῳ ἀντλειν τουτ' ἐστι. The authority of the New Testament (John, ii. 8; iv. 7, 11) is to the same effect. Here ἀντλημα is evidently something which the woman brought along with her, probably a bucket and rope.

Pump.

the weight of a pillar of water of this perpendicular height, and having the surface of the piston for its base.

Such is the simplest, and, we may add, by far the best, form of the forcing and lifting pumps; but it is not the most usual. Circumstances of convenience, economy, and more frequently of fancy and habit, have caused the pump-makers to deviate greatly from this form. It is not usual to have the working barrel in the water; this, especially in deep wells, makes it of difficult access for repairs, and requires long piston-rods. This would not do in a forcing pump, because they would bend.

Effect of giving the piston a longer stroke.

We have supposed, in our account of the lifting pump, that the rise of the piston always terminated at the surface of the water in the cistern. This we did in order that the barrel might always be filled by the pressure of the surrounding water. But let us suppose that the rise of the piston does not end here, and that it is gradually drawn up to the very top: it is plain that the pressure of the atmosphere is by this means taken off from the water in the pipe (see PNEUMATICS), while it remains pressing on the water of the cistern. It will therefore cause the water to follow the piston as it rises through the pipe, and it will raise it in this way thirty-three feet at a medium. If, therefore, the spout D is not more than thirty-three feet above the surface of the water in the cistern, the pipe will be full of water when the piston is at D. Let it be pushed down to the bottom; the water will remain in the pipe, because the valve G will shut: and thus we may give the piston a stroke of any length not exceeding thirty-three feet. If we raise it higher than this the water will not follow; but it will remain in the pipe, to be lifted by the piston, after it has been pushed down through it to the bottom.

But it is not necessary, and would be very inconvenient, to give the piston so long a stroke. The great use of a pump is to render effectual the reciprocation of a short stroke which we can command, while such a long stroke is generally out of our power. Suppose that the piston is pushed down only to *b*; it will then have a column *b*O incumbent on it, and it will lift this column when again drawn up. And this operation may be repeated like the former, when the piston was always under water; for the pressure of the atmosphere will always cause the water to follow the piston to the height of thirty-three feet.

Nor is it necessary that the fixed valve G be placed at the lower orifice of the pipe, nor even under water. For, while things are in the state now described, the piston drawn up to O, and the whole pipe full of water, if we suppose another valve placed at *b* above the surface of the cistern, this valve can do no harm. Now let the piston descend, both valves G and *b* will shut. G may now be removed, and the water will remain supported in the space *b*G by the air; and now the alternate motions of the piston will produce the same effect as before.

Effect of the weight of the water and pressure of the atmosphere.

We found in the former case that the piston was carrying a load equal to the weight of a pillar of water of the height A*d*, because the surrounding water could only support it at its own level. Let us see what change is produced by the assistance of the pressure of the atmosphere. Let the under surface of the piston be at *b*; when the water was at *f*, 33 feet above the surface of the cistern, the water was raised to that height by the pressure of the atmosphere. Suppose a partition made at *b* by a thin plate, and all the water above it taken away. Now pierce a hole in this plate. The pressure of the atmosphere was able to carry the whole column O*a*. Part of this column is now removed, and the remainder is not a balance for the air's pressure. This will therefore cause the water to spout up through this hole and rise to O. Therefore the under surface of this plate is pressed up by the contiguous water with a force equal to the weight of that pillar of water which it formerly supported; that is, with a force equal to the weight of the pillar O*b*. Now the under surface of the piston, when at *b*, is in the same situation. It is pressed upwards by the water below it, with a force equal to the weight of the column O*b*; but it is pressed downwards by the whole pressure of the atmosphere, which presses on all bodies, that is, with the weight of the pillar O*b*. On the whole, therefore, it is pressed downwards by a force equal to the difference of the weights of the pillars O*a* and O*b*; that is, by a force equal to the weight of the pillar *ba*.

Pump.

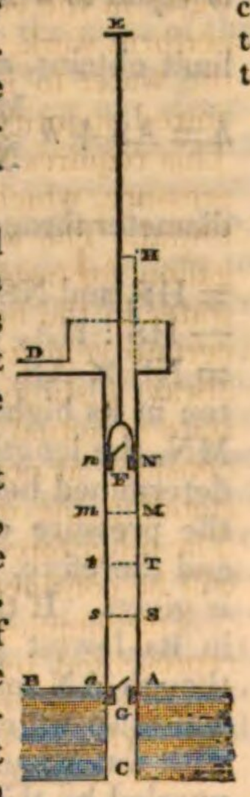
It may be conceived better perhaps in this way. When the piston was under the surface of the water in the cistern, it was equally pressed on both sides, both by the water and the atmosphere. The atmosphere exerted its pressure on it by the intervention of the water, which being to all sense a perfect fluid, propagates every external pressure undiminished. When the piston is drawn up above the surface of the pit-water, the atmosphere continues to press on its upper surface with its whole weight, through the intervention of the water which lies above it; and its pressure must therefore be added to that of the incumbent water. It also continues to press on the under surface of the piston by the intervention of the water; that is, it presses this water to the piston. But, in doing this, it carries the weight of this water which it is pressing on the piston. The pressure on the piston therefore is only the excess of the whole pressure of the atmosphere above the weight of the column of water which it is supporting. Therefore the difference of atmospherical pressure on the upper and under surfaces of the piston is precisely equal to the weight of the column of water supported in the pipe by the air. It is not, however, the individual weight of this column that loads the piston; it is the part of the pressure of the atmosphere on its upper surface, which is not balanced by its pressure on the under surface.

In attempting, therefore, to draw up the piston, we have to surmount this unbalanced part of the pressure of the atmosphere, and also the weight of the water which lies above the piston, and must be lifted by it; and thus the whole opposing pressure is the same as before, namely, the weight of the whole vertical pillar reaching from the surface of the water in the cistern to the place of delivery. Part of this weight is immediately carried by the pressure of the atmosphere; but, in lieu of it, there is an equal part of this pressure of the atmosphere abstracted from the under surface of the piston, whilst its upper surface sustains its whole pressure.

Other circumstances to be attended to.

So far, then, these two states of the pump agree. But they differ exceedingly in their mode of operation; and there are some circumstances not very obvious which must be attended to, in order that the pump may deliver any water at the spout D. This requires, therefore, a serious examination.

Fig. 4.



Let the fixed valve G (fig. 4) be supposed at the surface of the cistern water. Let M*m* be the lowest and N*n* the highest positions of the piston, and let HA = *h* be the height of a column of water equiponderant with the atmosphere.

When the pump is filled, not with water, but with air, and the piston is in its lowest position, and all in equilibrio, the internal air has the same density and elasticity with the external. The space MA*am*, therefore, contains air of the common density and elasticity. These may be measured by *h*, or the weight of a column of water whose height is *h*. Now, let the piston be drawn up to N*n*. The air which occupied the space MA*am* now occupies the space NA*an*, and its density is now $\frac{\text{MA}am}{\text{NA}an}$. Its elasticity is now dimi-

Pump. nished, being proportionable to its density (see PNEUMATICS), and no longer balances the pressure of the atmosphere. The valve G will therefore be forced up by the water, which will rise to some height SA. Now let the piston again descend to M*m*. It cannot do this with its valve shut; for when it comes down so far as to reduce the air again to its common density, it is not yet at M, because the space below it has been diminished by the water which got into the pipe, and is retained there by the valve G. The piston-valve, therefore, opens by the air which we thus attempt to compress, and the superfluous air escapes. When the piston has got to M, the air is again of the common density, and occupies the space MS*sm*. Now draw the piston up to N. The air will expand into the space NS*sn*, and its density will be reduced to $\frac{MSsm}{NSsn}$, and its elasticity will no longer balance the pressure of the atmosphere, and more water will enter, and it will rise higher. But it may happen that the water will never rise so high as to reach the piston, even though not thirty-three feet above the water in the cistern: for the successive diminutions of density and elasticity are a series of quantities that decrease geometrically, and therefore will have a limit. Let us see what determines this limit.

When the piston descends, its valve, as we have already seen, is opened by the force arising from the compression of the air below it. Now if this force should at length become equal to the pressure of the atmosphere above the valve, it is clear that the valve could not open. Supposing the water to be at S, and the piston at N; then, if, from the peculiar construction of the pump, it should so happen that the air which has been compressed into the space MS*sm*, by the descent of the piston, regains an elastic force merely equal to the pressure of the external air, the valve in the piston would remain closed, and consequently no more air could escape. Were the working of the piston, in such circumstances, to be continued, the air below it would alternately fill the spaces MS*sm* and NS*sn*, the water meanwhile rising no higher than S.

At whatever height the water stands in the lower part of the pipe, the weight of the column of water SA*as*, together with the remaining elasticity of the air above it, exactly balances the pressure of the atmosphere. (See PNEUMATICS.) Now the elasticity of the air in the space NS*sn* is equal to $h \times \frac{MSsm}{NSsn}$. Therefore, in the case where the limit obtains, and the water rises no farther, we must have $h = AS + h\frac{MSsm}{NSsn}$, or, because the column is of the same diameter throughout, $h = AS + h\frac{MS}{NS}$, and $\frac{MS}{NS}h = h - AS$, $= HS$, and $NS : MS = HA : HS$, and $NS - MS : NS = HA - HS : HA$, or $MN : NS = AS : AH$, and $MN \times AH = NS \times AS$. Therefore, if AN, the distance of the piston in its highest position from the water in the cistern, and MN, the length of its stroke, be given, there is a certain determined height AS to which the water can be raised by the pressure of the air: for AH is a constant quantity; and therefore, when MN is given, the rectangle $AS \times SN$ is given. If this height AS be less than that of the piston in its lowest position, the pump will raise no water, although AN may be less than AH. Yet the same pump will raise water very effectually, if it be first of all filled with water; and we have seen professional engineers much puzzled by this capricious failure of their pumps. A little knowledge of the principles would have prevented their disappointment.

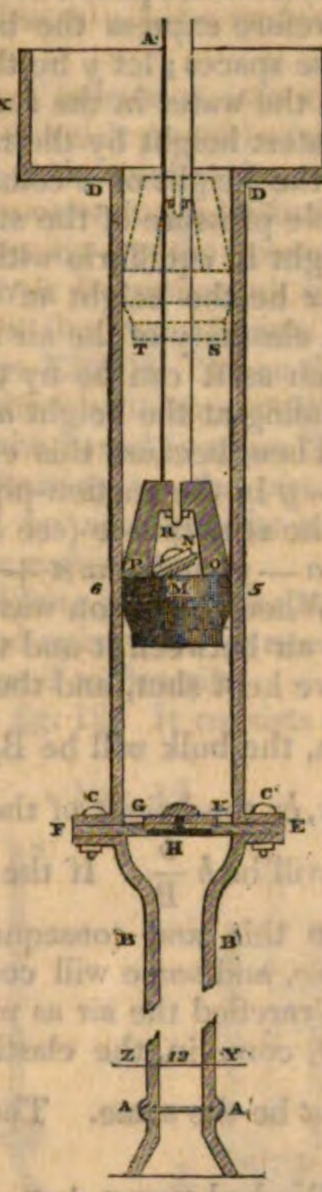
Delivery of water. To insure the delivery of water by the pump, the stroke must be such that the rectangle $MN \times AH$ may be greater than any rectangle that can be made of the parts of AN, that is, greater than the square of half AN. Or, if the length of the stroke be already fixed by other circumstances, which is a common case, we must make AN so short that the square of its half, measured in feet, shall be less than thirty-three times the stroke of the piston. Pump.

Suppose that the fixed valve, instead of being at the surface of the water in the cistern, is at S, or anywhere between S and A, the performance of the pump will be the same as before; but if it be placed anywhere above S, it will be very different. Let it be at T. It is plain that when the piston is pushed down from N to M, the valve at T prevents any air from getting down; and therefore, when the piston is drawn up again, the air contained in the space MT*tm* will expand into the space NT*tn*, and its density will be $\frac{MT}{NT}$. This is less than $\frac{MS}{NS}$, which expresses the density of the air which was left in the space TS*st* by the former operations. The air, therefore, in TS*st* will also expand, will open the valve, and now the water will rise above S. The proportion of NS to NT may be evidently such that the water will even get above the valve T. This diminishes the space NT*tn;* and therefore, when the piston has been pushed down to M, and again drawn up to N, the air will be still more rarefied, and the water will rise still higher. The foregoing reasoning, however, is sufficient to show that there may still be a height which the water will not pass, and that this height depends on the proportion between the stroke of the piston and its distance from the water in the cistern. We need not give the determination, because it will come in afterwards in combination with other circumstances. It is enough that the reader sees the physical causes of this limitation; and, lastly, we see plainly that the utmost security will be given for the performance of the pump, when the fixed valve is so placed that the piston, when in its lowest position, shall come into contact with it. In this case, the rarefaction of the air will be the completest possible; and if there were no space left between the piston and valve, and all were perfectly air-tight, the rarefaction would be complete, and the valve might be anything less than thirty-three feet from the surface of the water in the cistern.

Valves not easily kept air-tight. But this perfect contact and tightness is unattainable; and though the pump may be full of water, its continual downward pressure causes it to filtrate slowly through every crevice, and the air enters through every pore, and even disengages itself from the water, with which a considerable portion had been chemically combined. The pump by this means loses water, and it requires several strokes of brisk working to fill it again; and if the leathers have become dry, so much admission may be given to the air, that the pump will not fill itself with water by *any working*. It is then necessary to pour water into it, which shuts up these passages, and soon sets all to rights again. For these reasons, it is always prudent to place the fixed valve as low as other circumstances will permit, and to make the piston-rod of such a length, that when it is at the bottom of its stroke it shall be almost in contact with the valve. When we are not limited by other circumstances, it is evident that the best possible form is to have both the piston and the fixed valve under the surface of the water of the cistern. In this situation they are always wet and air-tight. The chief objection is, that by this disposition they are not easily come at when needing repair. This is a material objection in deep mines. In such situations, therefore, we must make the best compensation of different circumstances that we can. It is usual to place the fixed valve at a moderate distance from the surface of the water, and to have a hole in the side of the pipe, by which it may be got out. This is carefully shut up by a plate firmly screwed on, with leather or cement between the parts. This is called the *clack-door*.

Pump. It would, in every case, be very proper to have a fixed valve in the lower end of the pipe. This would combine all advantages. Being always tight, the pipe would retain the water, and it would leave to the valve above it its full effect of increasing the rarefaction. A similar hole is made in the working barrel, a little above the highest position of the piston. When this needs repair, it can be got at through this hole, without the immense trouble of drawing up the whole rods.

Fig. 5.



Thus we have conducted the reader, step by step, from the simplest form of the pump to that which long experience has at last selected as the most generally convenient. This we shall now describe in some detail.

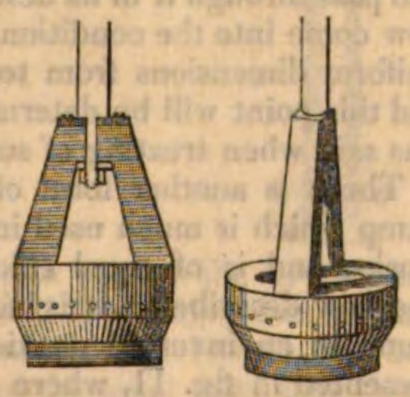
Description of the sucking pump.

The *sucking pump* consists of two pipes DCCD, BAAB (fig. 5); of which the former is called the *barrel*, or the *working barrel*, and the other is called the *suction-pipe*, and is commonly of a smaller diameter. These are joined by means of flanches E, F, pierced with holes to receive screwed bolts. A ring of leather, or of lead, covered with a proper cement, is put between them; which, being strongly compressed by the screw-bolts, renders the joint perfectly air-tight. The lower end A of the suction-pipe is commonly spread out a little to facilitate the entry of the water, and frequently has a grating across at AA to keep out filth or gravel. This is immersed in the standing water YZ. The working barrel is cylindrical, as evenly and smoothly bored as possible, that the piston may fill it exactly through its whole length, and move along it with as little friction as may be consistent with air-tightness.

Air-tightness not properly attended to.

The piston is a sort of truncated cone OPKL, generally made of wood not made to slip, such as elm or beech. The small end of it is cut off at the sides, so as to form a sort of arch OQP, by which it is fastened to the iron rod or spear. It is exhibited in different positions in figures 6, 7, which will give a more distinct notion of it than any description. The two ends of the conical part may be hooped with brass. This cone has its larger end surrounded with a ring or band of strong leather fastened with nails, or by a copper hoop, which is driven on it at the smaller end. This band should reach to some distance beyond the base of the cone; the farther the better; and the whole must be of uniform thickness all round, so as to suffer equal compression between the cone and the working barrel. The seam or joint of the two ends of this band must be made very close, but not sewed or stitched together. This would occasion bumps or inequalities, which would spoil its tightness; and no harm can result from the want of it, because the two edges will be squeezed close together by the compression in the barrel. It is by no means necessary that this compression be great. This is a very detrimental error of the pump-makers. It occasions enormous friction, and destroys the very purpose which they have in view, viz. rendering the piston air-tight; for it causes the leather to wear through very soon at the edge of the cone, and it also wears the working barrel. This very soon becomes wide in that part which is continually passed over by the piston, while the mouth remains of its original diameter, and it becomes impossible to thrust in a piston which shall completely fill the worn part.

Fig. 6. Fig. 7.



Pump.

An easy mode of rendering pumps tight.

Now, a very moderate pressure is sufficient for rendering the pump perfectly tight, and a piece of glove-leather would be sufficient for this purpose, if loose or detached from the solid cone; for suppose such a loose and flexible, but impervious, band of leather put round the piston, and put into the barrel; and let it even be supposed that the cone does not compress it in the smallest degree to its internal surface. Pour a little water carefully into the inside of this sort of cup or dish; it will cause it to swell out a little, and apply itself close to the barrel all round, and even adjust itself to all its inequalities. Let us suppose it to touch the barrel in a ring of an inch broad all round. We can easily compute the force with which it is pressed. It is half the weight of a ring of water an inch deep and an inch broad. This is a trifle, and the friction occasioned by it not worth regarding; yet this trifling pressure is sufficient to make the passage perfectly impervious, even by the most enormous pressure of a high column of incumbent water; for let this pressure be ever so great, the pressure by which the leather adheres to the barrel always exceeds it, because the incumbent fluid has no *preponderating* power by which it can force its way between them, and it must insinuate itself precisely so far that its pressure on the inside of the leather shall still exceed, and only exceed, the pressure by which it endeavours to insinuate itself; and thus the piston becomes perfectly tight with the smallest possible friction. This reasoning is perhaps too refined for the uninstructed artist, and probably will not persuade him. To such we would recommend an examination of the pistons and valves contrived and executed by that artist whose skill far surpasses our highest conceptions, the All-wise Creator of this world. The valves which shut up the passages of the veins, and this in places where an extravasation would be followed by instant death, are cups of thin membrane, which adhere to the sides of the channel about half way round, and are detached in the rest of their circumference. When the blood comes in the opposite direction, it pushes the membrane aside, and has a passage perfectly free. But a stagnation of motion allows the tone of the muscular (perhaps) membrane, to restore it to its natural shape, and the least *motion* in the opposite direction causes it instantly to clap close to the sides of the vein, and then no pressure whatever can force a passage.

Best form of a piston recommended.

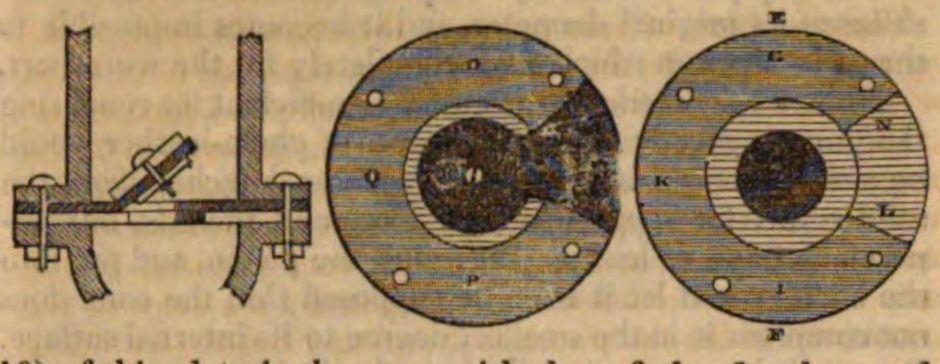
What we have said is enough for supporting our directions for constructing a tight piston. But we recommended thick and strong leather, while our present reasoning seems to render thin leather preferable. If the leather be thin, and the solid piston in any part does not press it gently to the barrel, there will be in this part an unbalanced pressure of the incumbent column of water, which would instantly burst even a strong leather bag: but when the solid piston, covered with leather, exactly fills the barrel, and is even pressed a little to it, there is no such risk; and now that part of the leather band which reaches beyond the solid piston performs its office in the completest manner. We do not hesitate, therefore, to recommend this form of a piston, which is the most common and simple of all, as preferable, when well executed, to any of those more artificial, and frequently very ingenious, constructions, which we have met with in the works of the first engineers. To proceed, then, with our description of the sucking pump.

Further description of the sucking pump.

At the joining of the working barrel with the suction-pipe there is a hole H, covered with a valve opening upwards. This hole H is either made in a plate which makes a part of the suction-pipe, being cast along with it, or it is

Pump. made in a separate plate. This last is the most convenient, being easily removed and replaced. Different views are given of this valve in figs. 8, 9, 10. The diameter EF (fig. 10) of this plate is the same with that of the flanches, and it has holes corresponding to them, through which their bolts pass, which keep all together. A ring of thick leather NKL is applied to this plate, having a part cut out between N and L, to make room for another piece of strong leather NR (fig. 9), which composes the valve. The circular part of this valve is broader than the hole in the middle of fig. 10, but not quite so broad as to fill up the inside of the ring of leather OQP of this figure, which is the same with GKI of fig. 10. The middle of this leather valve is strengthened by two brass (not iron) plates, the uppermost of which is seen at R of fig. 9; the one on its under side is a little smaller than the hole in the valve-plate, that it may go freely in; and the upper plate R is larger than this hole, that it may compress the leather to its brim all round. It is evident that when this plate with its leathers is put between the joint-flanches, and all is screwed together, the tail of leather N of fig. 9 will be compressed between the plates, and form a hinge, on which the valve can turn, rising and falling. There is a similar valve fastened to the upper side, or broadest base of the piston. This description serves for both valves, and in general for most valves which are to be found in any parts of a pump.

Fig. 8. Fig. 9. Fig. 10.



Its mode of operation. The reader will now understand, without any repetition, the process of the whole operation of a sucking pump. The piston rarefies the air in the working barrel, and that in the suction-pipe expands through the valve into the barrel; and, being no longer a balance for the atmospheric pressure, the water rises into the suction-pipe; another stroke of the piston produces a similar effect, and the water rises farther, but by a smaller step than by the preceding stroke; by repeating the strokes of the piston the water gets into the barrel; and when the piston is now pushed down through it, it gets above the piston, and may now be lifted up to any height. The suction-pipe is commonly of smaller size than the working barrel, for the sake of economy. It is not necessary that it be so wide; but it may be, and often is, made too small. It should be of such a size that the pressure of the atmosphere may be able to fill the barrel with water as fast as the piston rises. If a void is left below the piston, it is evident that the piston must be carrying the whole weight of the atmosphere, besides the water which is lying above it. Nay, if the pipe be only so wide that the barrels shall fill precisely as fast as the piston rises, it must sustain all this pressure. The suction-pipe should be wider than this, that all the pressure of the atmosphere which exceeds the weight of the pillar in the suction-pipe may be employed in pressing it on the under surface of the piston, and thus diminish the load. It cannot be made too wide; and too strict an economy in this respect may very sensibly diminish the performance of the pump, and more than defeat its own purpose. This is most likely when the suction-pipe is long, because there the length of the pillar of water nearly balances the air's pressure, and leaves very little accelerating force; so that water will rise but slowly even in the widest pipe. All these things will be made the subjects of computation afterwards.

Pump. It is plain that there will be limitations to the rise of the water in the suction-pipe, similar to what we found when the whole pump was an uniform cylinder. Let a be the height of the fixed valve above the water in the cistern; let B and b be the spaces in cubic measure between this valve and the piston in its highest and lowest positions, and therefore express the bulks of the air which may occupy these spaces; let y be the distance between the fixed valve and the water in the suction-pipe, when it has attained its greatest height by the rarefaction of the air above it; let h be the height of a column of water in equilibrio with the whole pressure of the atmosphere, and therefore having its weight in equilibrio with the elasticity of common air; and let x be the height of the column whose weight balances the elasticity of the air in the suction-pipe, when rarefied as much as it can be by the action of the piston, the water standing at the height $a - y$.

Then, because this elasticity, together with the column $a - y$ in the suction-pipe, must balance the whole pressure of the atmosphere (see PNEUMATICS), we must have $h = x + a - y$, and $y = a + x - h$.

When the piston was in its lowest position, the bulk of the air between it and the fixed valve was b. Suppose the valve kept shut, and the piston raised to its highest position, the bulk will be B, and its density $\frac{b}{B}$, and its elasticity, or the height of the column whose weight will balance it, will be $h\frac{b}{B}$. If the air in the suction-pipe be denser than this, and consequently more elastic, it will lift the valve, and some will come in; therefore, when the pump has rarefied the air as much as it can, so that none does, in fact, come in, the elasticity of the air in the suction-pipe *must* be the same. Therefore $x = h\frac{b}{B}$.

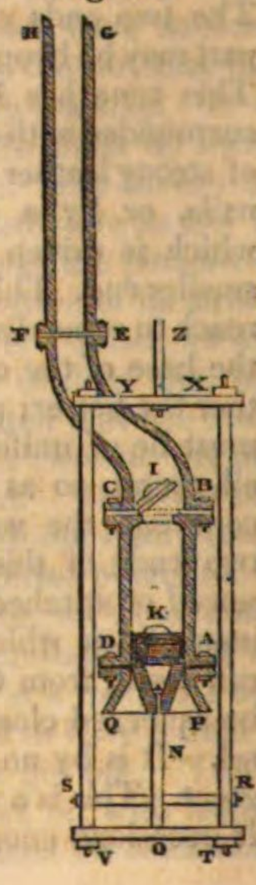
We had $y = a + x - h$. Therefore $y = a + h\frac{b}{B} - h$,

$$= a + \frac{b - B}{B}h, = a - \frac{B - b}{B}h.$$

Therefore, when $\frac{b - B}{B}h$ is less than a, the water will stop before it reaches the fixed valve. But when a is less than $\frac{B - b}{B}h$, the water will get above the fixed valve, y becoming negative.

But it does not follow that the water will reach the piston, that is, will rise so high that the piston will pass through it in its descent. Things now come into the condition of a pump of uniform dimensions from top to bottom; and this point will be determined by what was said when treating of such a pump.

Fig. 11.



The same pump is used in an inverted position.

There is another form of the sucking pump which is much used in great waterworks, and is of equal efficacy with the one now described. It is indeed the same pump in an inverted position. It is represented in fig. 11, where ABCD is the working barrel, immersed, with its mouth downwards, in the water of the cistern. It is joined by means of flanches to the rising pipe or *main*.

This usually consists of two parts. The first, BEFC, is bent to one side, that it may give room for the iron frame TXYV, which carries the rod NO of the piston M, attached to the traverses RS, TOV of this frame. The other part, EGHF, is usually of a less diameter, and is continued

Pump. to the place of delivery. The piston-frame X'TVY hangs by the rod Z, at the end of a lever or working beam, not brought into the figure. The piston is perforated like the former, and is surrounded, like it, with a band of leather in form of a taper-dish. It has a valve K on its broad or upper base, opening when pressed from below. The upper end of the working barrel is pierced with a hole, covered with a valve I, also opening upwards.

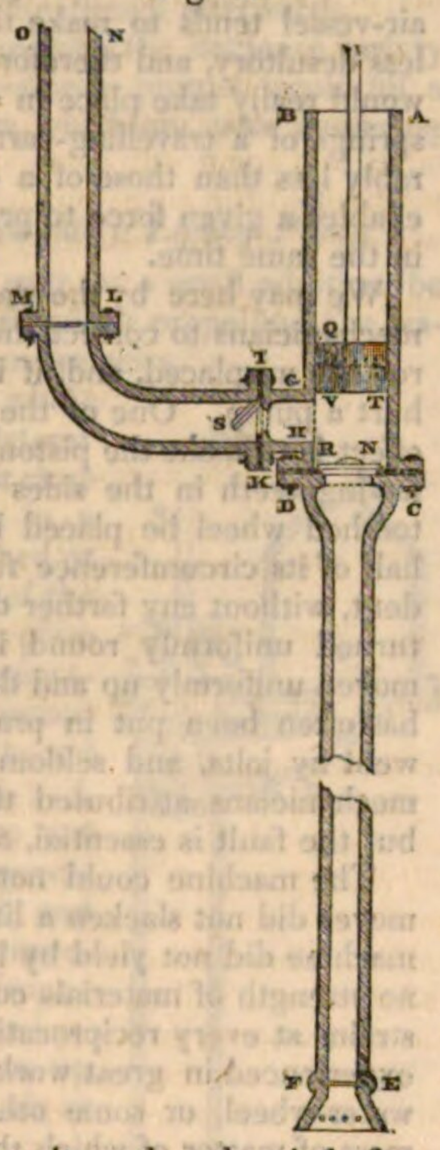
Now suppose this working apparatus immersed into the cistern, and the piston drawn up till it touch the end of the barrel. When the piston is allowed to descend by its own weight, the water rises up through its valve K, and fills the barrel. If the piston be now drawn up by the moving power of the machinery with which it is connected, the valve K shuts, and the piston pushes the water before it through the valve I into the main pipe EFGH. When the piston is again let down, the valve I shuts by its own weight and the water incumbent on it, and the barrel is again filled by the water of the cistern. Drawing up the piston pushes this water into the main pipe, &c. and then the water is at length delivered at the place required.

This pump is usually called the *lifting pump*; perhaps the simplest of all in its principles and operation. It needs no farther explanation: and we proceed to describe

Forcing pump described.

The *forcing pump*, represented in fig. 12. It consists of a working barrel ABCD, a suction-pipe CDEF, and a main or rising pipe. This last is usually in three joints. The first, GHKI, may be considered as making part of the working barrel, and is commonly cast in one piece with it. The second, IKLM, is joined to it by flanches, and forms the elbow which this pipe must generally have. The third, LNOM, is properly the beginning of the main, and is continued to the place of delivery. At the joint IK there is a hanging valve or clack S; and there is a valve R on the top of the suction-pipe.

Fig. 12.



The piston PQTV is solid, and is fastened to a stout iron rod, which goes through it, and is fixed by a key drawn through its end. The body of the piston is a sort of double cone, widening from the middle to each end, and is covered with two bands of very strong leather, fitted to it in the manner already described.

Its mode of operation.

The operation of this pump is abundantly simple. When the piston is thrust into the pump, it pushes the air before it through the valve S, for the valve R remains shut by its own weight. When it has reached near the bottom, and is drawn up again, the air which filled the small space between the piston and the valve S now expands into the barrel; for as soon as the air begins to expand, it ceases to balance the pressure of the atmosphere, which therefore shuts the valve S. By the expansion of the air in the barrel the equilibrium at the valve R is destroyed, and the air in the suction-pipe lifts the valve, and expands into the barrel; consequently it ceases to be a balance for the pressure of the atmosphere, and the water is forced into the suction-pipe. Pushing the piston down again forces the air in the barrel through the valve S, the valve R in the mean time shutting. When the piston is again drawn up, S shuts, R opens, the air in the suction-pipe dilates anew, and the water rises higher in it. Repeating these operations, the water gets at last into the working barrel, and is forced into the main by pushing down the piston, and is pushed along to the place of delivery. Pump.

The operation of this pump is therefore twofold, sucking and forcing. In the first operation, the same force must be employed as in the sucking pump, namely, a force equal to the weight of a column of water having the section of the piston for its base, and the height of the piston above the water in the cistern for its height. It is for the sake of this part of the operation that the upper cone is added to the piston. The air and water would pass by the sides of the lower cone whilst the piston is drawn up; but the leather of the upper cone applies to the surface of the barrel, and prevents this. The space contained between the barrel and the valve S is a great obstruction to this part of the operation, because this air cannot be rarefied to a very great degree. For this reason, the suction-pipe of a forcing pump must not be made long. It is not indeed necessary; for, by placing the pump a few feet lower, the water will rise into it without difficulty, and the labour of suction is as much diminished as that of impulsion is increased. However, an intelligent artist will always endeavour to make this space between the valve S and the lowest place of the piston as small as possible.

The power employed in forcing must evidently surmount the pressure of the whole water in the rising pipe, and (independent of what is necessary for giving the water the required velocity, so that the proper quantity per hour may be delivered) the piston has to withstand a force equal to the weight of a column of water having the section of the piston for its base, and the perpendicular altitude of the place of delivery above the lower surface of the piston for its height. It is quite indifferent in this respect what is the diameter of the rising pipe; because the pressure on the piston depends on the altitude of the water only, independent of its quantity. We shall even see that a small rising pipe will require a greater force to convey the water along it to any given height or distance.

When we would employ a pump to raise water in a crooked pipe, or in any pipe of moderate dimensions, this form of pump, or something equivalent, must be used. In bringing up great quantities of water from mines, the common sucking pump is generally employed, as really the best of them all; but it is the most expensive, because it requires the pipe to be perpendicular, straight, and of great dimensions, that it may contain the piston-rods. But this is impracticable when the pipe is crooked.

If the forcing pump, constructed in the manner now described, be employed, we cannot use forcers with long rods. These would bend when pushed down by their further extremity. In this case it is usual to employ only a short and stiff rod, and to hang it by a chain, and load it with a weight superior to the weight of water to be raised by it. The machinery therefore is employed, not in forcing the water along the rising pipe, but in raising the weight which is to produce this effect by its subsequent descent.

In this case it would be much better to employ the lifting pump of fig. 11; for as the load on the forcers must be greater than the resistances which it must surmount, the force exerted by the machine must in like manner be greater than this load. This double excess would be avoided by using the lifting pump.

Quantity of water delivered by any pump.

It will readily occur to the reader that the quantity of water delivered by any pump will be in the joint proportion of the surface or base of the piston and its velocity; for this measures the capacity of that part of the working barrel which the piston passes over. The velocity of the water in the conduit-pipe, and in its passage through every valve, will be greater or less than the velocity of the piston, in the

Pump.

same proportion that the area of the piston or working barrel is greater or less than the area of the conduit or valve. For whatever quantity of water passes through any section of the working barrel in a second, the same quantity must go through any one of these passages. This enables us to modify the velocity of the water as we please: we can increase it to any degree at the place of delivery by diminishing the aperture through which it passes, provided we apply sufficient force to the piston.

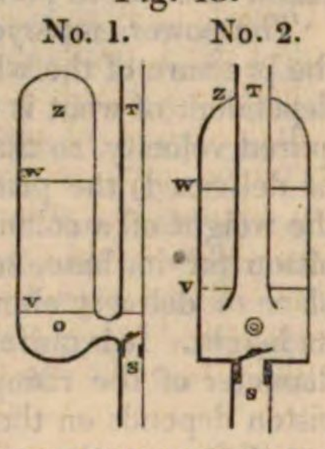
The operation of pumps not equable.

It is evident that the operation of a pump is by starts, and that the water in the main remains at rest, pressing on the valve during the time that the piston is withdrawn from the bottom of the working barrel. It is in most cases desirable to have this motion equable, and in some cases it is absolutely necessary. Thus, in the engine for extinguishing fires, the spout of water going by jerks could never be directed with a certain aim, and half of the water would be lost by the way; because a body at rest cannot in an instant be put in rapid motion, and the first portion of every jerk of water would have but a small velocity.

The mode of making them so.

A very ingenious contrivance has been fallen upon for obviating this inconvenience, and procuring a stream nearly equable. We have not been able to discover the author. At any convenient part of the rising pipe beyond the valve S there is annexed a capacious vessel VZ (fig. 13, No. 1 and 2) close a-top, and of great strength. When the water is forced along this pipe, part of it gets into this vessel, keeping the air confined above it; and it fills it to such a height V that the elasticity of the confined air balances a column reaching to T, we shall suppose, in the rising pipe. The next stroke of the piston sends forward more water, which would fill the rising pipe to some height above T. But the pressure of this additional column causes some more of it to go into the air-vessel, and compress its air so much more that its elasticity now balances a longer column. Every succeeding stroke of the piston produces a like effect. The water rises higher in the main pipe, but some more of it goes into the air-vessel. At last the water *appears* at the place of delivery; and the air in the air-vessel is now so much compressed that its elasticity balances the pressure of the whole column. The next stroke of the piston sends forward some more water. If the diameter of the orifice of the main be sufficient to let the water flow out with a velocity equal to that of the piston, it will so flow out, rising no higher, and producing no sensible addition to the compression in the air-vessel. But if the orifice of the main be contracted to half its dimensions, the water sent forward by the piston cannot flow out in the time of the stroke without a greater velocity, and therefore a greater force. Part of it, therefore, goes into the air-vessel, and increases the compression. When the piston has ended its stroke, and no more water comes forward, the compression of the air in the air-vessel, being greater than what was sufficient to balance the pressure of the water in the main pipe, now forces out some of the water which is lying below it. This cannot return towards the pump, because the valve S is now shut. It therefore goes forward along the main, and produces an efflux during the time of the piston's rising in order to make another stroke. In order that this efflux may be very equable, the air-vessel must be very large. If it be small, the quantity of water that is discharged by it during the return of the piston makes so great a portion of its capacity, that the elasticity of the confined air is too much diminished by this enlargement of its bulk, and the rate of efflux must diminish accordingly. The capacity of the air-vessel should be so great that the change of bulk of the compressed air during the inaction of the piston may be inconsiderable. It must therefore be very strong.

Fig. 13.



Pump.

It is pretty indifferent in what way this air-vessel is connected with the rising pipe. It may join it laterally, as in fig. 13, No. 1, and the main pipe go on without interruption; or it may be made to *surround* an interruption of the main pipe, as in fig. 13, No. 2. It may also be in any part of the main pipe. If the sole effect intended by it is to produce an equable jet, as in ornamental water-works, it may be near the end of the main. This will require much less strength, because there remains but a short column of water to compress the air in it. But it is, on the whole, more advantageous to place it as near the pump as possible, that it may produce an equable motion in the whole main pipe. This is of considerable advantage. When a column of water several hundred feet long is at rest in the main pipe, and the piston at one end of it is put at once into motion, even with a moderate velocity, the strain on the pipe must be very great. Indeed if it were possible to put the piston instantaneously into motion with a finite velocity, the strain on the pipe, tending to burst it, would be next to infinite.

The desultory motion of the pistons.

But this seems impossible in nature; all changes of motion *which we observe* are gradual, because all impelling bodies have some elasticity or softness, by which they yield to compression. And, in the way in which pistons are commonly moved, viz. by cranks, or something analogous to them, the motion is *very sensibly* gradual. But still the air-vessel tends to make the motion along the main pipe less desultory, and therefore diminishes those strains which would really take place in the main pipe. It acts like the springs of a travelling-carriage, whose jolts are incomparably less than those of a cart; and by this means really enables a given force to propel a greater quantity of water in the same time.

We may here by the way observe, that the attempts of mechanicians to correct this unequal motion of the piston-rod are misplaced, and, if it could be done, would greatly hurt a pump. One of the best methods of producing this effect is to make the piston-rod consist of two parallel bars, having teeth in the sides which front each other. Let a toothed wheel be placed between them, having only the half of its circumference furnished with teeth. It is evident, without any farther description, that if this wheel be turned uniformly round its axis, the piston-rod will be moved uniformly up and down without intermission. This has often been put in practice; but the machine always went by jolts, and seldom lasted a few days. Unskilled mechanicians attributed this to defect in the execution; but the fault is essential, and lies in the principle.

The machine could not perform one stroke if the first mover did not slacken a little, or the different parts of the machine did not yield by bending or by compression; and no strength of materials could withstand the violence of the strains at every reciprocation of the motion. This is chiefly experienced in great works which are put in motion by a water-wheel, or some other equal power exerted on the mass of matter of which the machine consists. The water-wheel being of great weight, moves with considerable steadiness or uniformity; and when an additional resistance is opposed to it by the beginning of a new stroke of the piston, its great quantity of motion is but little affected by this addition, and it proceeds very little retarded; and the machine must either yield a little by bending and compression, or go to pieces, which is the common event. Cranks are free from this inconvenience, because they accelerate the piston gradually, and bring it gradually to rest, while the water-wheel moves round with almost perfect uniformity. The only inconvenience (and it may be considerable) attending this slow motion of the piston at the beginning of its stroke is, that the valves do not shut with rapidity, so that some water gets back through them. But

Pump.

Equable pumps deliver very little more water than the others.

when they are properly formed and loaded, this is but trifling.

We must not imagine, that because the stream produced by the assistance of an air-barrel is almost perfectly equable, and because as much water runs out during the returning of the piston as during its active stroke, it therefore doubles the quantity of water. No more water can run out than what is sent forward by the piston during its effective stroke. The continued stream is produced only by preventing the whole of this water from being discharged during this time, and by providing a propelling force to act during the piston's return. Nor does it enable the moving force of the piston to produce a double effect; for the compression which is produced in the air-vessel, more than what is necessary for merely balancing the quiescent column of water, re-acts on the piston, resisting its compression just as much as the column of water would do which produces a velocity equal to that of the efflux. Thus if the water is made to spout with the velocity of eight feet per second, this would require an additional column of one foot high, and this would just balance the compression in the air-vessel, which maintains this velocity during the non-action of the piston. It is, however, a matter of fact, that a pump furnished with an air-vessel delivers a little more water than it would do without it. But the difference depends on the combination of many very dissimilar circumstances, which it is extremely difficult to bring into calculation. Some of these will be mentioned afterwards.

To describe, or even to enumerate, the immense variety of combinations of these three simple pumps, would fill a volume. We shall select a few, which are more deserving of notice.

1. *Sucking Pump converted into a Lifting Pump.*

The sucking pump converted into a lifting pump.

The common sucking pump may, by a small addition, be converted into a lifting pump, fitted for propelling the water to any distance, and with any velocity.

Fig. 14.

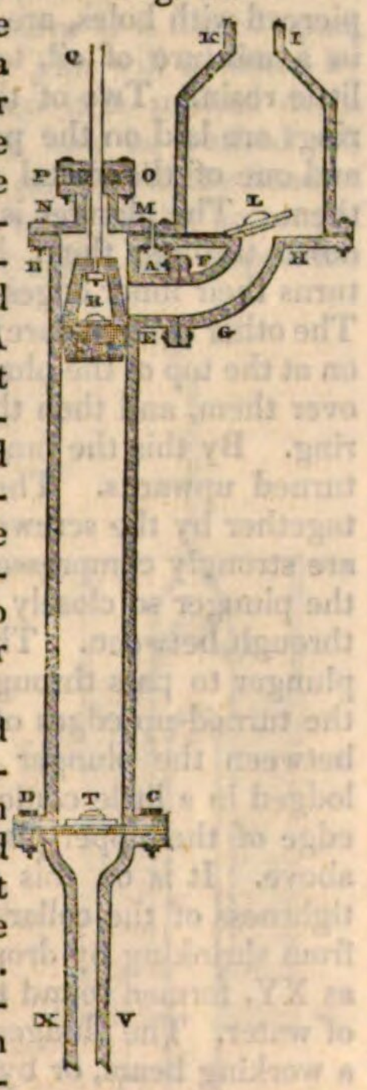


Fig. 14 is a sucking pump, whose working barrel ACDB has a lateral pipe AEGHF connected with it close to the top. This terminates in a *main* or rising pipe IK, furnished or not with a valve L. The top of the barrel is shut up by a strong plate MN, having a hollow neck terminating in a small flanch. The piston-rod QR passes through this neck, and is nicely turned and polished. A number of rings of leather are put over the rod, and strongly compressed round it by another flanch and several screwed bolts, as is represented at OP. By this contrivance the rod is closely grasped by the leathers, but may be easily drawn up and down, while all passage of air or water is effectually prevented.

The piston R is perforated, and furnished with a valve opening upwards. There is also a valve T on the top of the suction-pipe VX; and it will be of advantage, though not absolutely necessary, to put a valve L at the bottom of the rising pipe. Now, suppose the piston at the bottom of the working barrel. When it is drawn up, it tends to compress the air above it, because the valve in the piston remains shut by its own weight. The air therefore is driven through the valve L into the rising pipe, and escapes. In the mean time, the air which occupied the small space between the piston and the valve T expands into the upper part of the working barrel; and its elasticity is so much diminished thereby, that the atmosphere presses the water of the cistern into the suction-pipe, where it will rise till an equilibrium is again produced. The next downward stroke of the piston allows the air, which had come from the suction-pipe into the barrel during the ascent of the piston, to get through its valve. Upon drawing up the piston, this air is also drawn off through the rising pipe. Repeating this process brings the water at last into the working barrel, and it is then driven along the rising pipe by the piston.

Pump.

Advantages of this conversion.

This is one of the best forms of a pump. The rarefaction may be very perfect, because the piston can be brought so near to the bottom of the working barrel; and, for forcing water in opposition to great pressures, it appears preferable to the common forcing pump. because in that the piston-rods are compressed and exposed to bending, which greatly hurts the pump by wearing the piston and barrel on one side. This soon renders it less tight, and much water squirts out by the sides of the piston. But in this pump the piston-rod is always drawn or pulled, which keeps it straight; and rods exert a much greater force in opposition to a pull than in opposition to compression. The collar of leather round the piston-rods is found by experience to need very little repairs, and is very impervious to water. The whole is very accessible for repairs; and in this respect much preferable to the common pump in deep mines, where every fault of the piston obliges us to draw up some hundred feet of piston-rods. By this addition, too, any common pump for the service of a house is converted into an engine for extinguishing fire, or may be made to convey the water to every part of the house; and this without hurting or obstructing its common uses. All that is necessary is to have a large cock on the upper part of the working barrel, opposite to the lateral pipe in this figure. This cock serves for a spout when the pump is used for common purposes; and the merely shutting this cock converts the whole into an engine for extinguishing fire or for supplying distant places with water. It is scarcely necessary to add, that for these services it will be proper to connect an air-vessel with some convenient part of the rising pipe, in order that the current of the water may be continual.

Equable streams produced in great works by combinations.

We have frequently spoken of the advantages of a continued current in the main pipe. In all great works a considerable degree of uniformity is produced by the manner of disposing the actions of the different pumps; for it is very rarely that a machine works but one pump. In order to maintain some uniformity in the resistance, that it may not all be opposed at once to the moving power, with intervals of total inaction, which would produce a very hobbling motion, it is usual to distribute the work into portions, which succeed alternately; and thus both diminish the strain, and give greater uniformity of action, and frequently enable a natural power which we can command, to perform a piece of work which would be impossible if the whole resistance were opposed at once. In all pump machines, therefore, we are obviously directed to construct them so that they may give motion to at least two pumps, which work alternately. By this means a much greater uniformity of current is produced in the main pipe. It will be rendered still more uniform if four are employed, succeeding each other at the interval of one quarter of the time of a complete stroke.

A single pump for this purpose described.

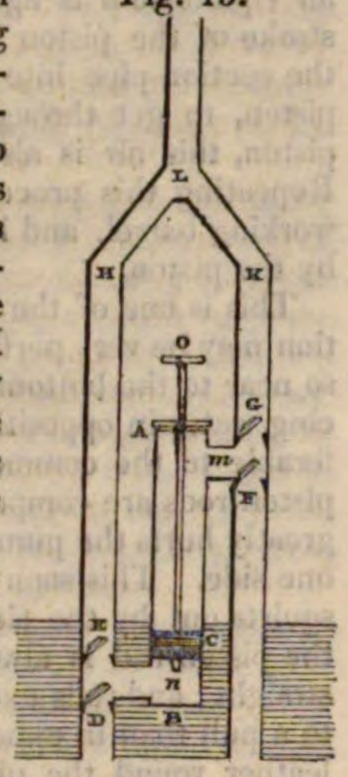
But ingenious men have attempted the same thing with a single pump, and many different constructions for this purpose have been proposed and executed, The thing is not of much importance, or of great research. We shall content ourselves, therefore, with the description of one that appears to us the most perfect, both in respect of simplicity and effect.

Pump.

2. *Description of a Pump with a continued current.*

It consists of a working barrel AB (fig. 15) close at both ends. The piston C is solid, and the rod O passes through a collar of leathers in the plate, which closes the upper end of the working barrel. This barrel communicates laterally with two pipes H, K; the communications *m* and *n* being as near to the top and bottom of the barrel as possible. Adjoining to the passage *m* are two valves F and G opening upwards. Similar valves accompany the passage *n*. The two pipes H and K unite in a larger rising pipe L. They are all represented as in the same plane; but the upper ends must be bent backwards, to give room for the motion of the piston-rod O.

Fig. 15.



Suppose the piston close to the entry of the lateral pipe *n*, and that it is drawn up; it compresses the air above it, and drives it through the valve G, where it escapes along the rising pipe; at the same time it rarefies the air in the space below it. Therefore the weight of the atmosphere shuts the valve E, and causes the water of the cistern to rise through the valve D, and fill the lower part of the pump. When the piston is pushed down again, this water is first driven through the valve E, because D immediately shuts; and then most of the air which was in this part of the pump at the beginning goes up through it, some of the water coming back in its stead. In the mean time, the air which remained in the upper part of the pump, after the ascent of the piston, is rarefied by its descent; because the valve G shuts as soon as the piston begins to descend, the valve F opens, the air in this suction-pipe F expands into the barrel, and the water rises into the pipes by the pressure of the atmosphere. The next rise of the piston must bring more water into the lower part of the barrel, and must drive a little more air through the valve G, namely, part of that which had come out of the suction-pipe F; and the next descent of the piston must drive more water into the rising pipe H, and along with it most if not all of the air which remained below the piston, and must rarefy still more the air remaining above the piston; and more water will come in through the pipe F, and get into the barrel. It is evident that a few repetitions will at last fill the barrel on both sides of the piston with water. When this is accomplished, there is no difficulty in perceiving how, at every rise of the piston, the water of the cistern will come in by the valve D, and the water in the upper part of the barrel will be driven through the valve G; and, in every descent of the piston, the water of the cistern will come into the barrel by the valve F, and the water below the piston will be driven through the valve E; and thus there will be a continual influx into the barrel through the valves D and F, and a continual discharge along the rising pipe L through the valves E and G.

It is equivalent to two forcing pumps.

This machine is, to be sure, equivalent to two forcing pumps, although it has but one barrel and one piston; but it has no sort of superiority. It is not even more economical in most cases; because we apprehend that the additional workmanship will fully compensate for the barrel and piston that is saved. There is indeed a saving in the rest of the machinery, because one lever produces both motions. We cannot, therefore, say that it is inferior to two pumps; and we acknowledge that there is some ingenuity in the contrivance.

Authors recommended.

We recommend to our readers the perusal of Belidor's *Architecture Hydraulique*, where is to be found a great variety of combinations and forms of the simple pumps; but we must caution them with respect to his theories, which in this article are extremely defective. Also in Leupold's *Theatrum Machinarum Hydraulicarum* there is a prodigious variety of all kinds of pumps, many of them very singular and ingenious, and many which have particular advantages, which may suit local circumstances, and give them a preference. But it would be improper to swell a work of this kind with so many peculiarities; and a person who makes himself master of the principles delivered here, in sufficient detail, can be at no loss to suit a pump to his particular views, or to judge of the merit of such as may be proposed to him.

Pump.

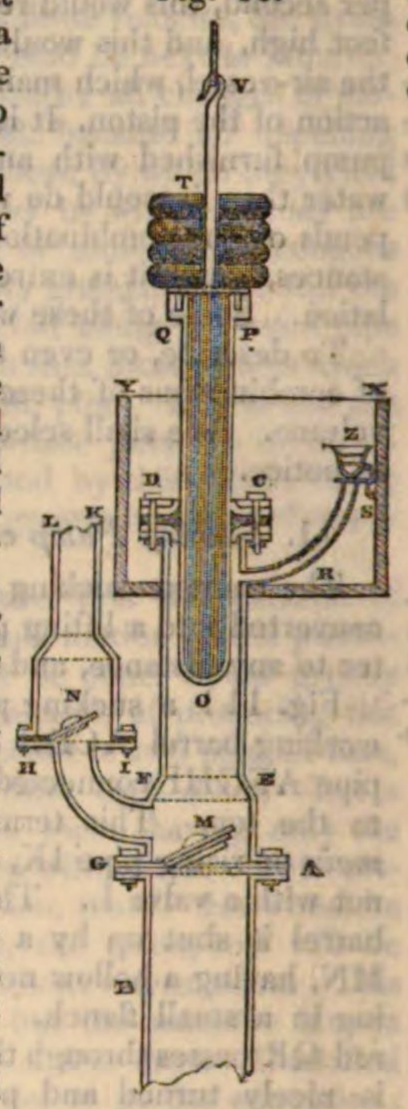
We must now take notice of some very considerable and important varieties in the form and contrivance of the essential parts of a pump.

3. *Description of an improved Forcing Pump.*

The forcing pump differently constructed.

The forcing pump is sometimes of a very different form from that already described. Instead of a piston, which applies itself to the inside of the barrel, and slides up and down in it, there is a long cylinder POQ (fig. 16) nicely turned and polished on the outside, and of a diameter somewhat less than the inside of the barrel. This cylinder (called a PLUNGER) slides through a collar of leathers on the top of the working barrel, and is constructed as follows. The top of the barrel terminates in a flanch *ab*, pierced with four holes for receiving screw-bolts. There are two rings of metal, of the same diameter, and having holes corresponding to those in the flanch. Four rings of soft leather, of the same size, and similarly pierced with holes, are well soaked in a mixture of oil, tallow, and a little rosin. Two of these leather rings are laid on the pump flanch, and one of the metal rings above them. The plunger is then thrust down through them, by which it turns their inner edges downwards. The other two rings are then slipped on at the top of the plunger, and the second metal ring is put over them, and then the whole are slid down to the metal ring. By this the inner edges of the last leather rings are turned upwards. The three metal rings are now forced together by the screwed bolts; and thus the leathern rings are strongly compressed between them, and made to grasp the plunger so closely that no pressure can force the water through between. The upper metal ring just allows the plunger to pass through it, but without any play; so that the turned-up edges of the leathern rings do not come up between the plunger and the upper metal ring, but are lodged in a little conical taper, which is given to the inner edge of the upper plate, its hole being wider below than above. It is on this trifling circumstance that the great tightness of the collar depends. To prevent the leathers from shrinking by drought, there is usually a little cistern, as XY, formed round the head of the pump, and kept full of water. The plunger is either forced down by a rod from a working beam, or by a set of metal weights laid on it, as is represented in the figure.

Fig. 16.



Its mode of operation.

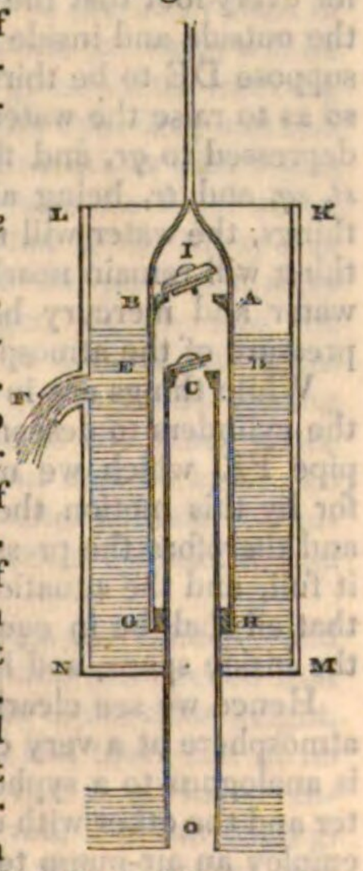
It is hardly necessary to be particular in explaining the operation of this pump. When the plunger is at the bottom of the barrel, touching the fixed valve M with its lower

Pump. extremity, it almost completely fills it. That it may do it completely, there is sometimes a small pipe RSZ branching out from the top of the barrel, and fitted with a cock at S. Water is admitted till the barrel is completely filled, and the cock is then shut. Now when the plunger is drawn up, the valve N in the rising pipe must remain shut by the pressure of the atmosphere, and a void must be made in the barrel. Therefore the valve M on the top of the suction-pipe must be opened by the elasticity of the air in this pipe, and the air must expand into the barrel; and being no longer a balance for the atmosphere, the water in the cistern must be forced into the suction-pipe, and rise in it to a certain height. When the plunger descends, it must drive the water through the valve N (for the valve M will immediately shut), and along with it most of the air which had come into the barrel. And as this air occupied the upper part of the barrel, part of it will remain when the plunger has reached the bottom; but a stroke or two will expel it all, and then every succeeding stroke of the descending piston will drive the water along the rising pipe, and every ascent of the plunger will be followed by the water from the cistern.

The advantage proposed by this form of piston is, that it may be more accurately made and polished than the inside of a working barrel, and it is of much easier repair. Yet we do not find that it is much used, although an invention of the seventeenth century (we think by Sir Samuel Morland), and much praised by the writers on these subjects.

Sucking pump similarly varied. It is easy to see that the sucking pump may be varied in the same way. Suppose this plunger to be open both at top and bottom, but the bottom filled with a valve opening upward. When this is pushed to the bottom of the barrel, the air which it tends to compress lifts the valve (the lateral pipe being taken away and the passage shut up), and escapes through the plunger. When it is drawn up, it makes the same rarefaction as the solid plunger, because the valve at O shuts, and the water will come up from the cistern as in the former case. If the plunger be now thrust down again, the valve M shuts, the valve O is forced open, and the plunger is filled with water. This will be lifted by it during its next ascent; and when it is pushed down again, the water which filled it must now be pushed out, and will flow over its sides into the cistern at the head of the barrel. Instead of making the valve at the bottom of the piston, it may be made at the top; but this disposition is much inferior, because it cannot rarefy the air in the barrel one half. This is evident; for the capacity of the barrel and plunger together cannot be twice the capacity of the barrel.

Fig. 17.



4. *Description of another form of the Forcing Pump.*

Another form of the sucking pump, and its mode of operation. It may be made after a still different form, as represented in fig. 17. Here the suction-pipe CO comes up through a cistern KMNL deeper or longer than the intended stroke of the piston, and has a valve C at top. The piston, or what acts in lieu of it, is a tube AHGB, open at both ends, and of a diameter somewhat larger than that of the suction-pipe. The interval between them is filled up at HG by a ring or belt of soft leather, which is fastened to the *outer* tube, and moves up and down with it, sliding along the smoothly polished surface of the suction-pipe with very little friction. There is a valve I on the top of this piston, opening upwards. Water is poured into the outer cistern. Pump.

The outer cylinder or piston being drawn up from the bottom, there is a great rarefaction of the air which was between them, and the atmosphere presses the water up through the suction-pipe to a certain height; for the valve I keeps shut by the pressure of the atmosphere and its own weight. Pushing down the piston causes the air, which had expanded from the suction-pipe into the piston, to escape through the valve I; drawing it up a second time allows the atmosphere to press more water into the suction-pipe, to fill it, and also part of the piston. When this is pushed down again, the water which had come through the valve C is now forced out through the valve I into the cistern KMNL, and now the whole is full of water. When, therefore, the piston is drawn up, the water follows, and fills it, if not thirty-three feet above the water in the cistern; and when it is pushed down again, the water which filled the piston is all thrown out into the cistern; and after this it delivers its full contents of water at every stroke. The water in the cistern KMNL effectually prevents the entry of any air between the two pipes; so that a very moderate compression of the belt of soft leather at the mouth of the piston-cylinder is sufficient to make all perfectly tight.

The piston-cylinder differently formed. It might be made differently. The ring of leather might be fastened round the top of the inner cylinder at DE, and slide on the inside of the piston cylinder; but the first form is easily executed. Muschenbroeck has given a figure of this pump in his large system of natural philosophy, and speaks very highly of its performance. But we do not see any advantage which it possesses over the common sucking pump. He indeed says that it is without friction, and makes no mention of the ring of leather between the two cylinders. Such a pump will raise water extremely well to a small height, and it seems to have been a model only which he had examined. But if the suction-pipe is long, it will by no means do without the leather; for on drawing up the piston, the water of the upper cistern will rise between the pipes and fill the piston, and none will come up through the suction-pipe.

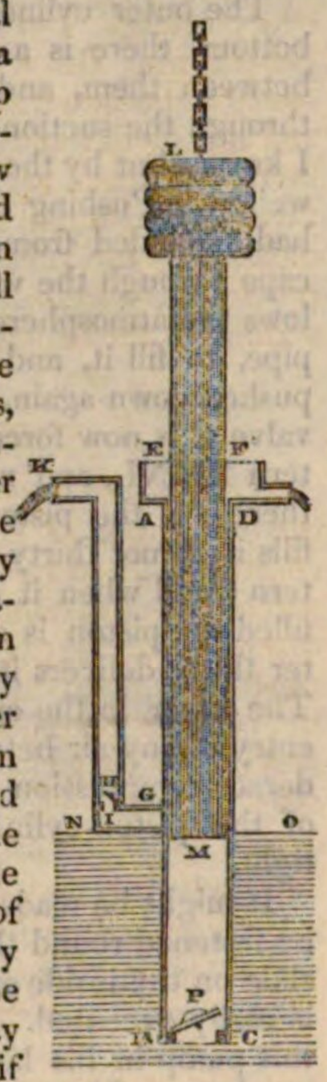
Pumps without friction not of important use. We may take this opportunity of observing, that the many ingenious contrivances of pumps without friction are of little importance in great works; because the friction which is completely sufficient to prevent all escape of water in a well-constructed pump, is but a very trifling part of the whole force. In the great pumps which are used in mines, and are worked by a steam-engine, it is very usual to make the pistons and valves without any leather whatever. The working barrel is bored truly cylindrical, and the piston is made of metal of a size that will just pass along it without sticking. When this is drawn up with the velocity competent to a properly loaded machine, the quantity of water which escapes round the piston is insignificant. The piston is made without leathers, not to avoid friction, which is also insignificant in such works; but to avoid the necessity of frequently drawing it up for repairs through such a length of pipes.

5. *Description of a Pump without Friction.*

Example of a pump without friction. If a pump absolutely without friction be wanted, the following seems preferable for simplicity and performance to any we have seen, when made use of in proper situations. Let NO (fig. 18) be the surface of the water in the pit, and K the place of delivery. The pit must be as deep in water as from K to NO. ABCD is a wooden trunk, round or square, open at both ends, and having a valve P at the bottom. The top of this trunk must be on a level with K, and has a small cistern EADF. It also communicates la-

Pump. terally with a rising pipe GHK, furnished with a valve at H opening upwards. LM is a beam of timber so fitted to the trunk as to fill it without sticking, and is of at least equal length. It hangs by a chain from a working beam, and is loaded on the top with weights exceeding that of the column of water which it displaces. Now suppose this beam allowed to descend from the position in which it is drawn in the figure; the water must rise all around it, in the crevice which is between it and the trunk, and also in the rising pipe, because the valve P shuts, and H opens; so that when the plunger has got to the bottom, the water will stand at the level of K. When the plunger is again drawn up to the top by the action of the moving power, the water sinks again in the trunk, but not in the rising pipe, because it is stopped by the valve H. Then allowing the plunger to descend again, the water must again rise in the trunk to the level of K, and it must now flow out at K; and the quantity discharged will be equal to the part of the beam below the surface of the pit-water, deducting the quantity which fills the small space between the beam and the trunk. This quantity may be reduced almost to nothing; for if the inside of the trunk and the outside of the beam be made tapering, the beam may be let down till they exactly fit; and as this may be done in square work, a good workman can make it exceedingly accurate. But in this case the lower half of the beam and trunk must not taper; and this part of the trunk must be of sufficient width round the beam to allow free passage into the rising pipe; or, which is better, the rising pipe must branch off from the bottom of the trunk. A discharge may be made from the cistern EADF, so that as little water as possible may descend along the trunk when the piston is raised.

Fig. 18.



Its excellencies are considerable, but it is limited.

One great excellence of this pump is, that it is perfectly free from all the deficiencies which in common pumps result from want of being air-tight. Another is, that the quantity of water raised is precisely equal to the power expended; for any want of accuracy in the work, while it occasions a diminution of the quantity of water discharged, makes an equal diminution in the weight which is necessary for pushing down the plunger. We have seen a machine consisting of two such pumps suspended from the arms of a long beam, the upper side of which was formed into a walk with a rail on each side. A man stood on one end till it got to the bottom, and then walked soberly up to the other end, the inclination being about twenty-five degrees at first, but gradually diminished as he went along, and changed the load of the beam. By this means he made the other end go to the bottom, and so on alternately, with the easiest of all exertions, and what we are most fitted for by our structure. With this machine, a very feeble old man, weighing 110 pounds, raised seven cubic feet of water eleven and a half feet high in a minute, and continued working eight or ten hours every day. A stout young man, weighing nearly 135 pounds, raised eight and a third to the same height; and when he carried thirty pounds conveniently slung about him, he raised nine and a fourth feet to this height, working ten hours a day without fatiguing himself. This exceeds Desagulier's maximum of a hogshead of water ten feet high in a minute, in the proportion of nine to seven nearly. It is limited to very moderate heights; but in such situations it is very effectual. It was the contrivance of an untaught labouring man, of uncommon mechanical genius. Pump.

6. *Description of Haskins's Quicksilver Pump.*

Haskins's pump described.

The most ingenious contrivance of a pump without friction is that of Mr Haskins, described by Desaguliers, and called by him the *Quicksilver Pump*. Its construction and mode of operation are pretty complicated; but the following preliminary observations will, we hope, render it abundantly plain.

Let *ilmk* (fig. 19) be a cylindrical iron pipe, about six feet long, open at top. Let *eghf* be another cylinder, connected with it at the bottom, and of smaller diameter. It may either be solid, or, if hollow, it must be close at top. Let *acdb* be a third iron cylinder, of an intermediate diameter, so that it may move up and down between the other two, without touching either, but with as little interval as possible. Let this middle cylinder communicate, by means of the pipe AB, with the upright pipe FE, having valves C and D (both opening upwards) adjoining to the pipe of communication. Suppose the outer cylinder suspended by chains from the end of a working beam, and let mercury be poured into the interval between the three cylinders till it fills the space to *op*, about three fourths of their height. Also suppose that the lower end of the pipe FE is immersed into a cistern of water, and that the valve D is less than thirty-three feet above the surface of this water.

Fig. 19.

Its mode of operation.

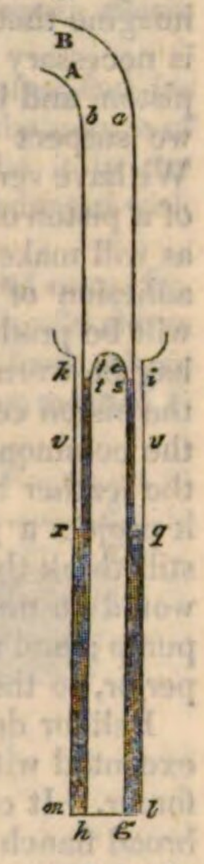
Now suppose a perforation made somewhere in the pipe AB, and a communication made with an air-pump. When the air-pump is worked, the air contained in CE, in AB, and in the space between the inner and middle cylinders, is rarefied, and is abstracted by the air-pump; for the valve D immediately shuts. The pressure of the atmosphere will cause the water to rise in the pipe CE, and will cause the mercury to rise between the inner and middle cylinders, and sink between the outer and middle cylinders. Let us suppose mercury twelve times heavier than water: then for every foot that the water rises in EC, the level between the outside and inside mercury will vary an inch; and if we suppose DE to be thirty feet, then, if we can rarefy the air so as to raise the water to D, the outside mercury will be depressed to *qr*, and the inside mercury will have risen to *st*, *sq*, and *tr*, being about thirty inches. In this state of things, the water will run over by the pipe BA, and everything will remain nearly in this position. The columns of water and mercury balance each other, and balance the pressure of the atmosphere.

While things are in this state of equilibrium, if we allow the cylinders to descend a little, the water will rise in the pipe FE, which we may now consider as a suction-pipe; for by this motion the capacity of the whole is enlarged, and therefore the pressure of the atmosphere will still keep it full, and the situation of the mercury will again be such that all shall be in equilibrio. It will be a little lower in the inside space, and higher in the outside.

Hence we see clearly how the water is supported by the atmosphere at a very considerable height. The apparatus is analogous to a syphon which has one leg filled with water and the other with mercury. But it was not necessary to employ an air-pump to fill it. Suppose it again empty, and all the valves shut by their own weight. Let the cylinders

Pump. descend a little. The capacity of the spaces below the valve D is enlarged, and therefore the included air is rarefied, and some of the air in the pipe CE must diffuse itself into the space quitted by the inner cylinder. Therefore the atmosphere will press some water up the pipe FE, and some mercury into the inner space between the cylinders. When the cylinders are raised again, the air which came from the pipe CE would return into it again, but is prevented by the valve C. Raising the cylinders to their former height would compress this air; it therefore lifts the valve D, and escapes. Another depression of the cylinders will have a similar effect. The water will rise higher in FC, and the mercury in the inner space; and then, after repeated strokes, the water will pass the valve C, and fill the whole apparatus, as the air-pump had caused it to do before. The position of the cylinders, when things are in this situation, is represented in fig. 20, the outer and inner cylinders in their lowest position having descended about thirty inches. The mercury in the outer space stands at *qr*, a little above the middle of the cylinders, and the mercury in the inner space is near the top *ts* of the inner cylinder. Now let the cylinders be drawn up. The water above the mercury cannot get back again through the valve C, which shuts by its own weight. We therefore attempt to compress it; but the mercury yields, and descends in the inner space and rises in the outer, till both are quickly on a level, about the height *vv*. If we continue to raise the cylinders, the compression forces out more mercury, and it now stands lower in the inner than in the outer space. But that there may be something to balance this inequality of the mercurial columns, the water goes through the valve D, and the equilibrium is restored when the height of the water in the pipe ED above the surface of the internal mercury is twelve times the difference of the mercurial columns (on the former supposition of specific gravity). If the quantity of water is such as to rise two feet in the pipe ED, the mercury in the outer space will be two inches higher than that in the inner space. Another depression of the cylinders will again enlarge the space within the apparatus, the mercury will take the position of fig. 19, and more water will come in. Raising the cylinders will send this water four feet up the pipe ED, and the mercury will be four inches higher in the inner than in the outer space. Repeating this operation, the water will be raised still higher in DE; and this will go on till the mercury in the outer space reaches the top of the cylinder; and this is the limit of the performance. The dimensions with which we set out will enable the machine to raise the water about thirty feet in the pipe ED, which, added to the thirty feet of CF, makes the whole height above the pit-water sixty feet. By making the cylinders longer, we increase the height of FD. This machine must be worked with great attention, and but slowly; for at the beginning of the forcing stroke the mercury very rapidly sinks in the inner space and rises in the outer, and will dash out and be lost. To prevent this as much as possible, the outer cylinder terminates in a sort of cup or dish, and the inner cylinder should be tapered a-top.

Fig. 20.



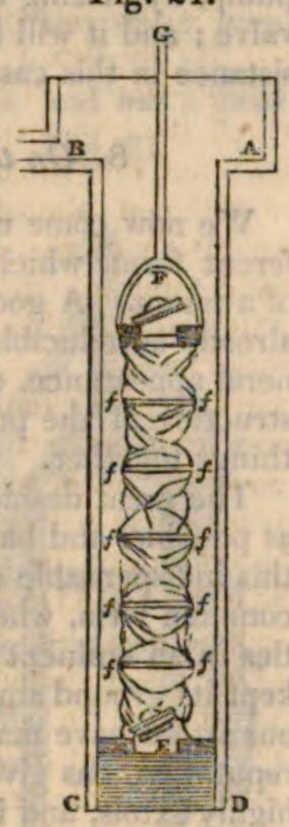
Ingenuity of the contrivance. The machine is exceedingly ingenious and refined; and there is no doubt but that its performance will exceed that of any other pump which raises the water to the same height, because friction is completely avoided, and there can be no want of tightness of the piston. But this is all its advantage; and, from what has been observed, it is but trifling. The expense would be enormous; for, with whatever care the cylinders are made, the interval between the inner and outer cylinders must contain a very great quantity of mercury. The middle cylinder must be made of iron plate, and must be without a seam, for the mercury would dissolve every solder. For such reasons, it has never come into general use. But it would have been unpardonable to have omitted the description of an invention which is so original and ingenious; and there are some occasions where it may be of great use, as, in nice experiments for illustrating the theory of hydraulics, it would give the finest pistons for measuring the pressures of water in pipes, &c. It is on precisely the same principle that the cylinder bellows, described in the article PNEUMATICS, are constructed. Pump.

7. *Simple Pump without Friction.*

Description of another pump without friction. We beg leave to conclude this part of the subject with the description of a pump without friction, which may be constructed in a variety of ways by any common carpenter, without the assistance of the pump-maker or plumber, and will be very effective for raising a great quantity of water to small heights, as in draining marshes, marl-pits, quarries, &c. or even for the service of a house.

ABCD (fig 21) is a square trunk of carpenter's work, open at both ends, and having a little cistern and spout at top. Near the bottom there is a partition made of board, perforated with a hole E, and covered with a clack. *ffff* represents a long cylindrical bag or pudding, made of leather, or of double canvass with a fold of thin leather such as sheep-skin between the canvass bags. This is firmly nailed to the board E, with soft leather between. The upper end of this bag is fixed on a round board, having a hole and valve F. This board may be turned in the lathe with a groove round its edge, and the bag fastened to it by a cord bound tight round it. The fork of the piston-rod FG is firmly fixed into this board; the bag is kept distended by a number of wooden hoops or rings of strong wire *ff*, *ff*, *ff*, &c. put into it at a few inches distance from each other. It will be proper to connect these hoops before putting them in, by three or four cords from top to bottom, which will keep them at their proper distances. Thus will the bag have the form of a barber's bellows powder-puff. The distance between the hoops should be about twice the breadth of the rim of the wooden ring to which the upper valve and piston-rod are fixed.

Fig. 21.



Its mode of operation. Now let this trunk be immersed in the water. It is evident, that if the bag be stretched from the compressed form which its own weight will give it, by drawing up the piston-rod, its capacity will be enlarged, the valve F will be shut by its own weight, the air in the bag will be rarefied, and the atmosphere will press the water into the bag. When the rod is thrust down again, this water will come out by the valve F, and fill part of the trunk. A repetition of the operation will have a similar effect; the trunk will be filled, and the water will at last be discharged by the spout.

Here is a pump without friction, and perfectly tight, for the leather between the folds of canvass renders the bag impervious both to air and water; and the canvass has very considerable strength. We know from experience that a bag of six inches diameter, made of sail-cloth No. 3, with a sheep-skin between, will bear a column of fifteen feet of water, and stand six hours work per day for a month without failure; and that the pump is considerably superior in effect to a common pump of the same dimensions. We must only observe, that the length of the bag must be three

Pump. times the intended length of the stroke; so that when the piston-rod is in its highest position, the angles or ridges of the bag may be pretty acute. If the bag be more stretched than this, the force which must be exerted by the labourer becomes much greater than the weight of the column of water which he is raising. If the pump be laid aslope, which is very usual in these occasional and hasty drawings, it is necessary to make a guide for the piston-rod within the trunk, that the bag may play up and down without rubbing on the sides, which would quickly wear it out.

The experienced reader will see that this pump is very like that of Gosset and De la Deuille, described by Belidor, vol. ii. p. 120, and most writers on hydraulics. It would be still more like it if the bag were on the under side of the partition E, and a valve placed farther down the trunk. But we think that our form is greatly preferable in point of strength. When in the other situation, the column of water lifted by the piston tends to burst the bag, and this with a great force, as the intelligent reader well knows. But in the form recommended here, the bag is *compressed*, and the strain on each part may be made much less than that which tends to burst a bag of six inches diameter. The nearer the rings are placed to each other the smaller will the strain be.

The same bag-piston may be employed for a forcing pump, by placing it below the partition, and inverting the valve; and it will then be equally strong, because the resistance in this case too will act by compression.

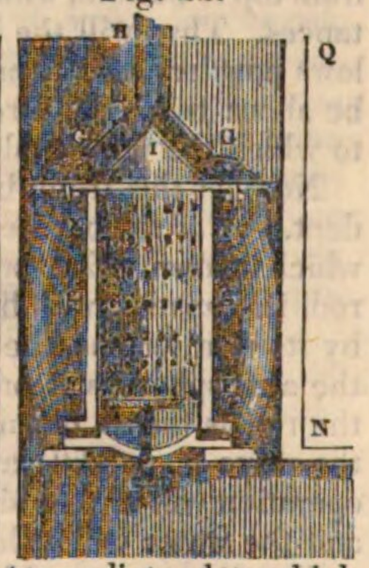
8. *On the different Forms of Pistons.*

We now come naturally to the consideration of the different forms which may be given to the pistons and valves of a pump. A good deal of what we have been describing already is reducible to this head; but, having a more general appearance, changing as it were the whole form and structure of the pump, it was not improper to keep these things together.

Pistons should have little friction.

The great desideratum in a piston is, that it be as tight as possible, and have as little friction as is consistent with this indispensable quality. We have already said that the common form, when carefully executed, has these properties in an eminent degree. And accordingly this form has kept its ground amidst all the improvements which ingenious artists have made. Mr Belidor, an author of the first reputation, has given the description of a piston which he highly extols, and is undoubtedly a very good one, constructed from principle, and extremely well composed.

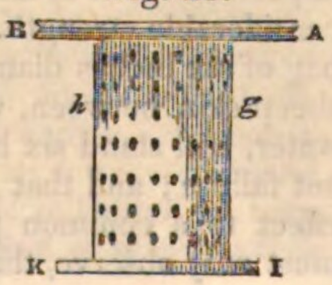
Fig. 22.



Improved one by Belidor.

It consists of a hollow cylinder of metal *g h* (fig. 23) pierced with a number of holes, and having at top a flanch AB, whose diameter is nearly equal to that of the working barrel of the pump PQ (fig. 22). This flanch has a groove round it. There is another flanch IK below, by which this hollow cylinder is fastened with bolts to the lower end of the piston, represented in fig. 23. This consists of a plate with a grooved edge similar to AB, and an intermediate plate which forms the seat of the valve. The composition of this part is better understood by inspecting the figure than by any description. The piston-rod HL is fixed to the upper plate by bolts through its different branches at G, G. This metal body is then covered with a cylindrical bag of leather fastened on it by cords bound round it, filling up the grooves in the upper and lower plates. The operation of the piston is as follows.

Fig. 23.



Pump. Its defects.

A little water is poured into the pump, which gets past the sides of the piston, and lodges below in the fixed valve. The piston being pushed down, dips into this water, and it gets into it by the valve. But as the piston in descending compresses the air below it, this compressed air also gets into the inside of the piston, swells out the bag which surrounds it, and compresses it to the sides of the working barrel. When the piston is drawn up again, it must remain tight, because the valve will shut and keep in the air in its most compressed state; therefore the piston must perform well during the suction. It must act equally well when pushed down again, and acting as a forcer; for, however great the resistance may be, it will affect the air within the piston to the same degree, and keep the leather close applied to the barrel. There can be no doubt, therefore, of the piston's performing both its offices completely; but we imagine that the adhesion to the barrel will be greater than is necessary: it will extend over the whole surface of the piston, and be equally great in every part of its surface, and we suspect that the friction will therefore be very great. We have very high authority for supposing that the adhesion of a piston of the common form, carefully made, will be such as will make it perfectly tight; and it is evident that the adhesion of Belidor's piston will be much greater, and it will be productive of worse consequences. If the leather bag be worn through in any one place, the air escapes, and the piston ceases to be compressed altogether; whereas in the common piston there will very little harm result from the leather being worn through in one place, especially if it project a good way beyond the base of the cone. We still think the common piston preferable. Belidor's piston would do much better inverted as the piston of a sucking pump; and in this situation it would be equal, but not superior, to the common.

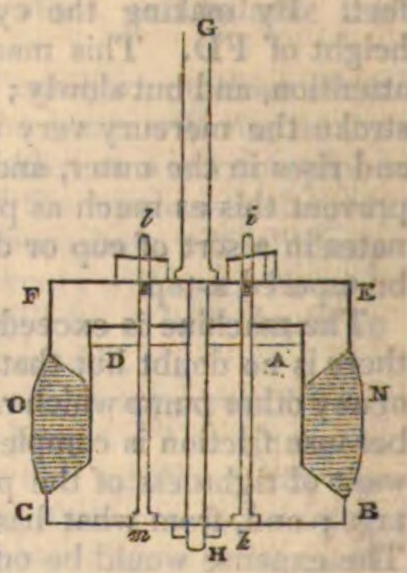
Another by the same author, objectionable.

Belidor describes another forcing piston, which he had executed with success, and prefers to the common wooden forcer. It consists of a metal cylinder or cone, having a broad flanch united to it at one end, and a similar flanch which is screwed on the other end. Between these two plates are a number of rings of leather strongly compressed by the two flanches, and then turned in a lathe like a block of wood, till the whole fits tight, when dry, into the barrel. It will swell, says he, and soften with the water, and withstand the greatest pressures. We cannot help thinking this but an indifferent piston. When it wears, there is nothing to squeeze it to the barrel. It may indeed be taken out and another ring or two of leather put in, or the flanches may be more strongly screwed together; but all this may be done with any kind of piston, and this has therefore no peculiar merit.

Another recommended as preferable.

The following will, we presume, appear vastly preferable. ABCD (fig. 24) is the solid wooden or metal block of the piston; EF is a metal plate, which is turned hollow or dish-like below, so as to receive within it the solid block. The piston-rod goes through the whole, and has a shoulder above the plate EF, and a nut H below. Four screw-bolts, such as *i k*, *l m*, also go through the whole, have their heads *k*, *m* sunk into the block, and nuts above at *i*, *l*. The packing, or stuffing as it is termed by the workmen, is represented at NO. This is made as solid as possible, and generally consists of soft hempen twine well soaked in a mixture of oil, tallow, and

Fig. 24.



Pump.

rosin. The plate EF is gently screwed down, and the whole is then put into the barrel, fitting it as tight as may be thought proper. When it wears loose, it may be tightened at any time by screwing down the nuts *i*, *l*, which cause the edges of the dish to squeeze out the packing, and compress it against the barrel to any degree.

Difficulties in constructing pistons.

The greatest difficulty in the construction of a piston is to give a sufficient passage through it for the water, and yet allow a firm support for the valve, and fixture for the piston-rod. We shall see presently that it occasions a considerable expense of the moving power to force a piston with a narrow perforation through the water lodged in the working barrel. When we are raising water to a small height, such as ten or twenty feet, the power so expended amounts to a fourth part of the whole, if the water-way in the piston is less than one half of the section of the barrel, and the velocity of the piston two feet per second, which is very moderate. There can be no doubt, therefore, that metal pistons are preferable, because their greater strength allows much wider apertures.

These considerably removed in one described by Belidor.

The following piston, described and recommended by Belidor, seems as perfect in these respects as the nature of things will allow. We shall therefore describe it in the author's own words as a model, which may be adopted with confidence in the greatest works.

"The body of the piston is a truncated metal cone (fig. 25), having a small fillet at the greater end. Fig. 26 shows the profile, and fig. 27 the plan of its upper base, where appears a cross-bar DD, pierced with an oblong mortise E

Fig. 25.

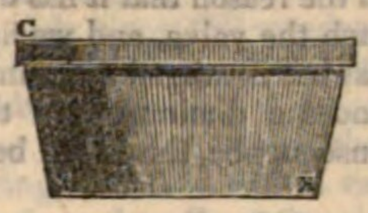


Fig. 26.

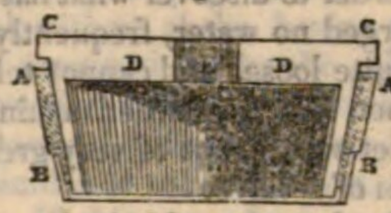


Fig. 27.

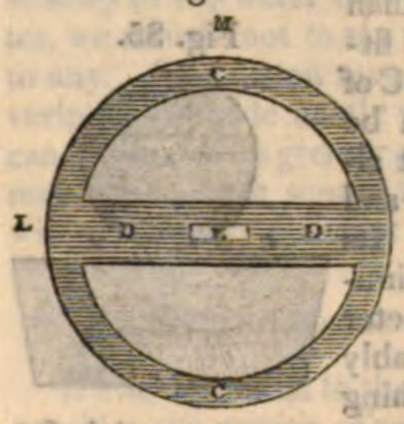
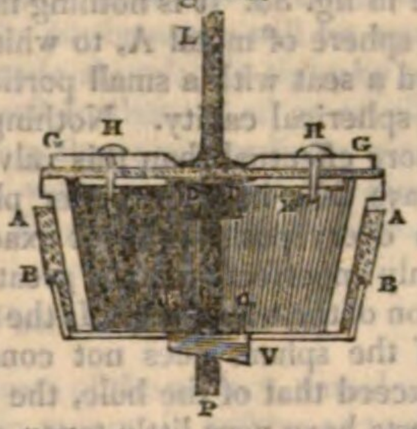


Fig. 28.



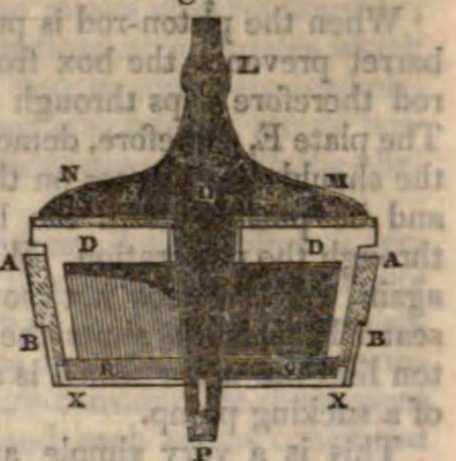
for receiving the tail of the piston-rod. A band of thick and uniform leather AA (figs. 26 and 28) is put round this cone, and secured by a brass hoop BB firmly driven on its smaller end, where it is previously made thinner to give room for the hoop.

"This piston is covered with a leather valve fortified with metal plates GG (fig. 29). These plates are wider than the hole of the piston, so as to rest on its rim. There are similar plates below the leather, of a smaller size, that they may go into the hollow of the piston; and the leather is firmly held between the metal plates by screws H, H, which go through all. This is represented by the dotted circle IK. Thus the pressure of the incumbent column of water is supported by the plates GG, whose circular edges rest on the brim of the water-way, and their straight edges rest on the cross bar DD of figs. 26 and 27. This valve is laid on the top of the conical box, in such a manner that its middle FF rests on the cross bar. To bind all together, the end of the piston-rod is formed like a cross, and the arms MN (fig. 30) are made to rest on the diameter FF of the valve, the tail EP going through the hole E in the middle of the leather, and through the mortise E of the cross bar of the box, and also through another bar QR (figs. 28 and 30) which is notched into the lower brim of the box. A key V is then driven into the hole T in the piston-rod, and this wedges all fast. The bar QR is made strong; and its extremities project a little, so as to support the brass hoop BB which binds the leather band to the piston-box. The adjoining scale gives the dimensions of all the parts, as they were executed for a steam-engine near Condé, where the piston gave complete satisfaction."

Fig. 29.

Pump.

Fig. 30.



This piston has every advantage of strength, tightness, and large water-way. The form of the valve, which has given it the name of the *butterfly-valve*, is extremely favourable to the passage of the water; and as it has but half the motion of a complete circular valve, less water goes back while it is shutting.

Advantage of this piston.

The following piston is also ingenious, and has a good deal of merit. OPPO (fig. 31) is the box of the piston, having a perforation Q, covered above with a flat valve K, which rests in a metal plate that forms the top of the box. ABCBA is a stirrup of iron to which the box is fixed by screws *a*, *a*, *a*, *a*, whose heads are sunk in the wood. This stirrup is perforated at C, to receive the end of the piston-rod, and a nut H is screwed on below to keep it fast. DEFED is another stirrup, whose lower part at DD forms a hoop like the sole of a stirrup, which embraces a small part of the top of the wooden box. The lower end of the piston-rod is screwed; and before it is put into the holes of the two stirrups (through which holes it slides freely) a broad nut G is screwed on it. It is then put into the holes, and the nut H firmly screwed up. The packing RR is then wound about the piston as tight as possible, till it completely fills the working barrel of the pump. When long use has rendered it in any degree loose, it may be tightened again by screwing down the nut G. This causes the ring DD to compress the packing between it and the projecting shoulder of the box at PP; and thus causes it to swell out, and apply itself closely to the barrel.

Another ingenious and useful piston described.

Fig. 31.

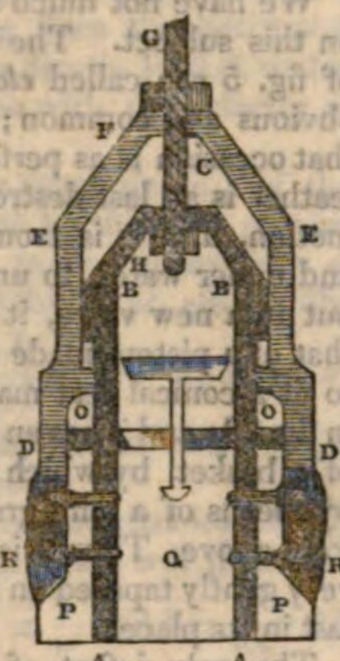
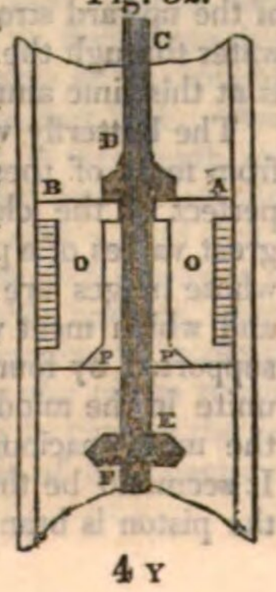


Fig. 32.



We shall add only another form of a perforated piston; which being on a principle different from all the preceding, will suggest many others, each of which will have its peculiar advantages. OO in fig. 32 represents the box of this piston, fitted to the working barrel in any of the preceding ways, as may be thought best. AB is a cross bar of four arms, which is fixed to the top of the box. CF is the piston-rod going through a hole in the middle of AB, and reaching a little way beyond the bottom of the box. It has a shoulder D, which prevents its going too far through.

Another on a different principle.

Pump. On the lower end there is a thick metal plate, turned conical on its upper side, so as to fit a conical seat PP in the bottom of the piston-box.

When the piston-rod is pushed down, the friction on the barrel prevents the box from immediately yielding. The rod therefore slips through the hole of the cross-bar AB. The plate E, therefore, detaches itself from the box. When the shoulder D presses on the bar AB, the box must yield, and be pushed down the barrel, and the water gets up through the perforation. When the piston-rod is drawn up again, the box does not move till the plate E lodge in the seat PP, and thus shuts the water-way; and then the piston lifts the water which is above it, and acts as the piston of a sucking pump.

Advantages of this. This is a very simple and effective construction, and makes a very tight valve. It has been much recommended by engineers of the first reputation, and is frequently used; and from its simplicity, and the great solidity of which it is capable, it seems very fit for great works. But it is evident that the water-way is limited to less than one half of the area of the working barrel. For if the perforation of the piston be one half of the area, the diameter of the plate or ball EF must be greater, and therefore less than half the area will be left for the passage of the water by its sides.

9. *Description of Valves.*

Valves. The requisites of a valve are, that it shall be tight, of sufficient strength to resist the great pressures to which it is exposed, that it afford a sufficient pressure for the water, and that it do not allow much to go back while it is shutting.

Clack-valves. We have not much to add to what has been said already on this subject. The valves which accompany the pump of fig. 5 are called *clack-valves*, and are of all the most obvious and common; and the construction described on that occasion is as perfect as any. We only add, that as the leather is at last destroyed at the hinge by such incessant motion, and it is troublesome, especially in deep mines, and under water, to undo the joint of the pump in order to put in a new valve, it is frequently annexed to a box like that of a piston, made a little conical on the outside, so as to fit a conical seat made for it in the pipe, as represented in fig. 33; and it has an iron handle A like that of a basket, by which it can be laid hold of by means of a long grappling-hook let down from above. Thus it is drawn up; and being very gently tapered on the sides, it sticks very fast in its place.

Fig. 33.

Defect in them. The only defect of this valve is, that by opening very wide when pushed up by the stream of water, it allows a good deal to go back during its shutting again. In some great machines which are worked by a slow turning crank, the return of the piston is so very slow that a sensible loss is incurred by this; but it is nothing like what Dr Desaguliers says, one half of a cylinder whose height is equal to the diameter of the valve. For in such machines, the last part of the upward stroke is equally slow, and the velocity of the water through the valve exceedingly small, so that the valve is at this time almost shut.

Utility of the butter-fly-valve. The butterfly valve, represented in fig. 29, &c. is free from most of these inconveniences, and seems the most perfect of the clack-valves. Some engineers make their great valves of a pyramidal form, consisting of four clacks, whose hinges are in the circumference of the water-way, and which meet with their points in the middle, and are supported by four ribs which rise up from the sides, and unite in the middle. This is an excellent form, affording the most spacious water-way, and shutting very readily. It seems to be the best possible for a piston. The rod of the piston is branched out on four sides, and the branches go through the piston-box, and are fastened below with screws. These branches form the support for the four clacks. We have seen a valve of this form in a pump of six feet diameter, which discharged twenty hogsheads of water at every stroke, and made twelve strokes in a minute, raising the water above twenty-two feet. Pump.

There is another form of valve, called the button or tail valve. It consists of a plate of metal AB (fig. 34) turned conical, so as exactly to fit the conical cavity *a b* of its box. A tail CD projects from the under side, which passes through a cross-bar EF in the bottom of the box, and has a little knob at the end, to hinder the valve from rising too high. Button valves.

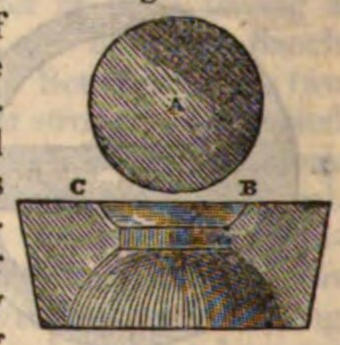
Fig. 34.

This valve, when nicely made, is unexceptionable. It has great strength, and is therefore proper for all severe strains, and it may be made perfectly tight by grinding. Accordingly it is used in all cases where this is of indispensable consequence. It is most durable, and the only kind that will do for passages where steam or hot water is to go through. Its only imperfection is a small water-way, which, from what has been said, cannot exceed, or indeed equal, one half of the area of the pipe.

If we endeavour to enlarge the water-way, by giving the cone very little taper, the valve frequently sticks so fast in the seat that no force can detach it. And this sometimes happens during the working of the machine; and the jolts and blows given to the machine in taking it to pieces, in order to discover what has been the reason that it has discharged no water, frequently detach the valve, and we find it quite loose, and cannot tell what has deranged the pump. When this is guarded against, and the diminution of the water-way is not of very great consequence, this is the best form of a valve.

A very simple valve described. Analogous to this is the simplest of all valves, represented in fig. 35. It is nothing more than a sphere of metal A, to which is fitted a seat with a small portion BC of a spherical cavity. Nothing can be more effectual than this valve; it always falls into its proper place, and in every position fits it exactly. Its only imperfection is the great diminution of the water-way. If the diameter of the sphere does not considerably exceed that of the hole, the touching parts have very little taper, and it is very apt to stick fast. It opposes much less resistance to the passage of the water than the flat under surface of the button-valve. *N. B.* It would be an improvement of that valve to give it a taper shape below like a boy's top. The spherical valve must not be made too light, otherwise it will be hurried up by the water, and much may go back while it is returning to its place.

Fig. 35.



A valve by Belidor uniting every requisite. Belidor describes with great minuteness (vol. ii. p. 221, &c.) a valve which unites every requisite. But it is of such nice and delicate construction, and its defects are so great when this exactness is not attained, or is impaired by use, that we think it hazardous to introduce it into a machine in a situation where an intelligent and accurate artist is not at hand. For this reason we have omitted the description, which cannot be given in few words, nor without many figures; and desire our curious readers to consult that author, or peruse Dr Desagulier's translation of this passage. Its principle is precisely the same with the following rude contrivance, with which we shall conclude the descriptive part of this article.

Suppose ABCD (fig. 36) to be a square wooden trunk. EF is a piece of oak board, exactly fitted to the trunk in

Pump.

Another valve on the same principle.

an oblique position, and supported by an iron pin which goes through it at I, one third of its length from its lower extremity E. The two ends of this board are bevelled, so as to apply exactly to the sides of the trunk. It is evident, that if a stream of water come in the direction BA, its pressure on the part IF of this board will be greater than that upon EI. It will therefore force it up and rush through, making it stand almost parallel to the sides of the trunk. To prevent its rising so far, a pin must be put in its way. When this current of water changes its direction, the pressure on the upper side of the board being again greatest on the portion IF, it is forced back again to its former situation; and its two extremities rising on the opposite sides of the trunk, the passage is completely stopped. This board therefore performs the office of a valve; and this valve is the most perfect that can be, because it offers the freest passage to the water, and it allows very little to get back while it is shutting; for the part IE brings up half as much water as IF allows to go down. It may be made extremely tight, by fixing two thin fillets H and G to the sides of the trunk, and covering those parts of the board with leather which applies to them; and in this state it perfectly resembles Belidor's fine valve.

Fig. 36.

Description of an occasional pump easily constructed.

And this construction of the valve suggests, by the way, a form of an occasional pump, which may be quickly set up by any common carpenter, and will be very effectual in small heights. Let *a b c d e* (fig. 36) be a square box made to slide along this wooden trunk without shake, having two of its sides projecting upwards, terminating like the gable-ends of a house. A piece of wood *e* is mortised into these two sides, and to this the piston-rod is fixed. This box being furnished with a valve similar to the one below, will perform the office of a piston. If this pump be immersed so deep in the water that the piston shall also be under water, we scruple not to say that its performance will be equal to any. The piston may be made abundantly tight by covering its outside neatly with soft leather. And as no pipe can be bored with greater accuracy than a very ordinary workman can make a square trunk, we presume that this pump will not be very deficient even for a considerable suction.

10. *Motion of Water in Pumps.*

The motion of water in pumps.

We now proceed to the last part of the subject, namely, to consider the motion of water in pumps, in reference to the force which must be employed. What we have hitherto said with respect to the force which must be applied to a piston, related only to the sustaining the water at a certain height: but in actual service we must not only do this, but we must discharge it at the place of delivery in a certain quantity; and this must require a force superadded to what is necessary for its mere support at this height.

The theory denominated *Hydrodynamics.*

This is an extremely intricate and difficult subject, and very imperfectly understood even by professed engineers. The principles on which this knowledge must be founded are of a much more abstruse nature than the ordinary laws of hydrostatics; and all the genius of Newton was employed in laying the foundation of this part of physical science. It has been much cultivated in the course of this century by the first mathematicians of Europe. Daniel and John Bernoulli have written very elaborate treatises on the subject, under the very apposite name of *Hydrodynamics;* in which, although they have added little or nothing to the fundamental propositions established in some sort by Newton, and acquiesced in by them, yet they have greatly contributed to our progress in it by the methods which they have pursued in making application of those fundamental propositions to the most important cases. It must be acknowledged, however, that both these propositions, and the extensions given them by these authors, are supported by a train of argument that is by no means unexceptionable; and that they proceed on assumptions or postulates which are but nearly true in any case, and in many are inadmissible: and it remains to this hour a wonder or puzzle how these propositions and their results correspond with the phenomena which we observe.

Pump.

But fortunately this correspondence does obtain to a certain extent. And it seems to be this correspondence chiefly which has given these authors, with Newton at their head, the confidence which they place in their respective principles and methods; for there are considerable differences among them in those respects, and each seems convinced that the others are in a mistake. MM. d'Alembert and Lagrange have greatly corrected the theories of their predecessors, and have proceeded on postulates which come much nearer to the real state of the case. But their investigations involve us in such an inextricable maze of analytical investigation, that, even when we are again conducted to the light of day by the clue which they have given us, we can make no use of what we there discovered.

But this theory, imperfect as it is, is of great service. It generalizes our observations and experiments, and enables us to compose a *practical doctrine* from a heap of facts which otherwise must have remained solitary and unconnected.

Fundamental proposition.

The fundamental proposition of this practical hydrodynamics is, that water or any fluid contained in an open vessel of indefinite magnitude, and impelled by its weight only, will flow through a small orifice with the velocity which a heavy body would acquire by falling from the horizontal surface of the fluid. Thus, if the orifice is 16 feet under the surface of the water, it will issue with the velocity of 32 feet in a second.

Its velocity corresponding to any other depth h of the orifice under the surface, will be had by this easy proportion: As the square root of 16 is to the square root of h, so is 32 feet to the velocity required: or, alternately,

$$\sqrt{16} : 32 = \sqrt{h} : v, \text{ and } v = \frac{32\sqrt{h}}{\sqrt{16}}, = \frac{32}{4}\sqrt{h}, = 8\sqrt{h};$$

that is, multiply the square root of the height in feet by 8, and the product is the required velocity.

On the other hand, it frequently occurs that we want to discover the depth under the surface which will produce a known velocity v. Therefore, $\sqrt{h} = \frac{v}{8}$, and $h = \frac{v^2}{64}$; that is, divide the square of the velocity by 64, and the quotient is the depth wanted in feet.

Its utility.

This proposition is sufficient for all our purposes. For, since water is nearly a perfect fluid, and propagates all impressions undiminished, we can, in place of any pressure of a piston or other cause, substitute a perpendicular column of water whose weight is equal to this pressure, and will therefore produce the same efflux. Thus, if the surface of a piston is half a square foot, and it be pressed down with the weight of 500 pounds, and we would wish to know with what velocity it would cause the water to flow through a small hole, we know that a column of water of this weight, and of half a foot base, would be sixteen feet high. And this proposition teaches us, that a vessel of this depth will have a velocity of efflux equal to thirty-two feet in a second.

If therefore our pressing power be of such a kind that it can continue to press forward the piston with the force of 500 pounds, the water will flow with this velocity, whatever be the size of the hole. All that remains is, to determine what change of actual pressure on the piston results from the motion on the piston itself, and to change the velocity of efflux in the subduplicate ratio of the change of actual pressure.

Pump.

But before we can apply this knowledge to the circumstances which take place in the motion of water in pumps, we must take notice of an important modification of the fundamental proposition, which is but very obscurely pointed out by any good theory, but is established on the most regular and unexceptionable observation.

If the efflux is made through a hole in a thin plate, and the velocity is computed as above, we shall discover the quantity of water which issues in a second by observing, that it is a prism or cylinder of the length indicated by the velocity, and having its transverse section equal to that of the orifice. Thus, in the example already given, supposing the hole to be a square inch, the solid contents of this prism, or the quantity of water issuing in a second, is $1 \times 32 \times 12$ cubic inches, or 384 cubic inches. This we can easily measure by receiving it in a vessel of known dimensions. Taking this method, we uniformly find a deficiency of nearly thirty-eight parts in a hundred; that is, if we should obtain a hundred gallons in any number of seconds, we shall in fact get only sixty-two. This is a most regular fact, whether the velocities are great or small, and whatever be the size and form of the orifice. The deficiency increases indeed in a very minute degree with the velocities. If, for instance, the depth of the orifice be one foot, the discharge is $\frac{6213}{10000}$; if it be fifteen feet, the discharge is $\frac{6172}{10000}$.

This deficiency is not owing to a diminution of velocity; for the velocity may be easily and accurately measured by the distance to which the jet will go if directed horizontally. This is found to correspond very nearly with the proposition, making a very small allowance for friction at the border of the hole, and for the resistance of the air. Sir Isaac Newton ascribed the deficiency with great justice to this, that the lateral columns of water, surrounding the column which is incumbent on the orifice, press towards the orifice, and contribute to the expense equally with that column. These lateral filaments, therefore, issue obliquely, crossing the motion of the central stream, and produce a contraction of the jet; and the whole stream does not acquire a parallel motion and its ultimate velocity till it has got to some distance from the orifice. Careful observation showed him that this was really the case. But even his genius could not enable him to ascertain the motion of the lateral filaments by theory, and he was obliged to measure everything as he saw it. He found the diameter of the jet at the place of the greatest contraction to be precisely such as accounted for the deficiency. His explication has been unanimously acquiesced in; and experiments have been multiplied to ascertain all those circumstances which our theory cannot determine *a priori*. The most complete set of experiments are those of Michelotti, made at Turin at the expense of the prince of Piedmont. Here jets were made of one, two, three, and four inches diameter; and the water received into cisterns most accurately formed of brick, and lined with stucco. It is the result of these experiments which we have taken for a measure of the deficiency.

We may therefore consider the water as flowing through a hole of this contracted dimension, or substitute this for the real orifice in all calculations. For it is evident, that if a mouth-piece (so to call it) were made, the internal shape of which precisely tallied with the form which the jet assumes, and if this mouth-piece be applied to the orifice, the water will flow out without any obstruction. The vessel may therefore be considered as really having this mouth-piece.

Nay, from this we derive a very important observation, that if, instead of allowing the water to flow through a hole of an inch area made in a thin plate, we make it flow through a hole in a thick plank, so formed that the external orifice shall have an inch area, but be widened internally agreeably to the shape which nature forms, both the velocity and quantity will be that which the fundamental proposition determines. Michelotti measured with great care the form of the great jets of three and four inches diameter, and found that the bounding curve was an elongated trochoid. He then made a mouth-piece of this form for his jet of one inch, and another for his jet of two inches; and he found the discharges to be $\frac{979}{1000}$ and $\frac{987}{1000}$; and he, with justice, ascribed the trifling deficiency which still remained, partly to friction and partly to his not having exactly suited his mouth-piece to the natural form. We imagine that this last circumstance was the sole cause: For, in the first place, the water in his experiments, before getting at his jet-holes, had to pass along a tube of eight inches diameter. Now a jet of four inches bears too great a proportion to this pipe; and its narrowness undoubtedly hindered the lateral columns from contributing to the efflux in their due proportion, and therefore rendered the jet less convergent. And, in the next place, there can be no doubt (and the observations of Daniel Bernoulli confirm it), but that this convergency begins within the vessel, and perhaps at a very considerable distance from the orifice. And we imagine, that if accurate observations could be made on the motion of the remote lateral particles within the vessel, and an internal mouth-piece were shaped according to the curve which is described by the remotest particle that we can observe, the efflux of water would almost perfectly tally with the theory. But indeed the coincidence is already sufficiently near for giving us very valuable information. We learn that the quantity of water which flows through a hole, in consequence of its own weight, or by the action of any force, may be increased one half by properly shaping the passage to this hole; for we see that it may be increased from sixty-two to near ninety-nine.

But there is another modification of the efflux, which we confess our total incapacity to explain. If the water issues through a hole made in a plate whose thickness is about twice the diameter of the hole, or, to express it better, if it issues through a pipe whose length is about twice its diameter, the quantity discharged is nearly $\frac{82}{100}$ of what results from the proposition. If the pipe be longer than this, the quantity is diminished by friction, which increases as the length of the pipe increases. If the pipe be shorter, the water will not fill it, but detaches itself at the very entry of the pipe, and flows with a contracted jet. When the pipe is of this length, and the extremity is stopped with the finger, so that it begins to flow with a full mouth, no subsequent contraction is observed; but merely striking on the pipe with a key or the knuckle is generally sufficient to detach the water in an instant from the sides of the pipe, and reduce the efflux to $\frac{62}{100}$.

This effect is most unaccountable. It certainly arises from the mutual adhesion or attraction between the water and the sides of the pipe; but how this, acting at right angles to the motion, should produce an increase from sixty-two to eighty-two, nearly one third, we cannot explain. It shows, however, the prodigious force of this attraction, which in the space of two or three inches is able to communicate a great velocity to a very great body of water. Indeed the experiments on capillary tubes show that the mutual attraction of the parts of water is some thousands of times greater than their weight.

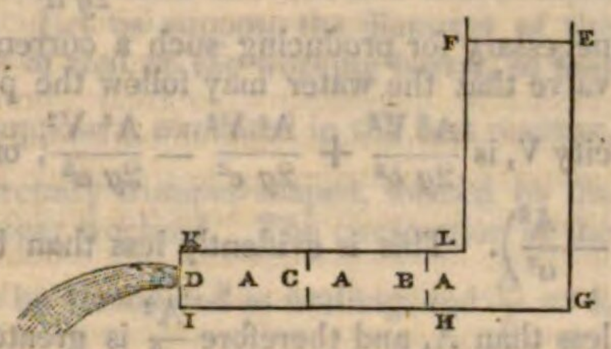
We have only further to add, that every increase of pipe beyond two diameters is accompanied with a diminution of the discharge; but in what ratio this is diminished it is very difficult to determine. We shall only observe at present, that the diminution is very great. A pipe of two inches diameter and thirty feet long has its discharge only $\frac{54}{100}$ of what it would be if only four inches long. If its length be sixty feet, its discharge will be no more than $\frac{50}{100}$. A pipe of one inch diameter would have a discharge of $\frac{44}{100}$ and $\frac{31}{100}$ in the same situation. Hence we may conclude that the discharge of a four-inch pipe of thirty feet long will not

Pump. exceed two thirds of what it would be if only eight inches long.

Before we can proceed to apply this fundamental proposition to our purpose, we must anticipate a proposition of continual use in the construction of *water-works*.

Let water be supposed stagnant in a vessel EFGH (fig. 37), and let it be allowed to flow out by a cylindrical pipe HIKL, divided by any number of partitions B, C, D, &c. Whatever be the areas B, C, D, of these orifices, the velocity in the intermediate parts of the pipe will be the same; for as much passes through any one orifice in a second as passes through any other in the same time, or through any section of the intervening pipe. Let this velocity in the pipe be V, and let the area of the pipe be A. The velocity in the orifices B, C, D, must be $\frac{VA}{B}$, $\frac{VA}{C}$, $\frac{VA}{D}$, &c. Let g be the velocity acquired in a second by a heavy body. Then, by the general proposition, the height of water in the vessel which will produce the velocity $\frac{VA}{B}$ in the first orifice alone, is $\frac{V^2}{2g}\frac{A^2}{B^2}$. After this passage the velocity is again reduced to V in the middle of the space between the first and second orifices. In the second orifice this velocity is changed to $\frac{VA}{C}$. This alone would have required a height of water $\frac{V^2}{2g}\frac{A^2}{C^2}$. But the water is already moving with the velocity V, which would have resulted from a height of water in the vessel (which we shall, in the language of the art, call the *head of water*) equal to $\frac{V^2}{2g}$. Therefore there is only required a head of water $\frac{V^2}{2g}\frac{A^2}{C^2} - \frac{V^2}{2g}$, or $\frac{V^2}{2g} \times \sqrt{\frac{A^2}{C^2}} - 1$. Therefore the whole height necessary for producing the efflux through both orifices, so as still to preserve the velocity V in the intervening pipe, is $\frac{V^2}{2g} \times \sqrt{\frac{A^2}{B^2} + \frac{A^2}{C^2}} - 1$. In like manner, the third orifice D would alone require a head of water $\frac{V^2}{2g} \times \sqrt{\frac{A^2}{D^2}} - 1$; and all the three would require a head $\frac{V^2}{2g} \times \sqrt{\frac{A^2}{B^2} + \frac{A^2}{C^2} + \frac{A^2}{D^2}} - 2$. By this induction may easily be seen what head is necessary for producing the efflux through any number of orifices.

Fig. 37.



Let the expense or quantity of water discharged in an unit of time (suppose a second) be expressed by the symbol Q. This is measured by the product of the velocity and by the area of the orifice, and is therefore $= VA$, or $\frac{VA}{B} \times B$, or $\frac{VA}{C} \times C$, &c. and $V^2 = \frac{Q^2}{A^2}$. Therefore we may compute the head of water (which we shall express by H) in reference to the quantity of water discharged, because this is generally the interesting circumstance. In this view we have $H = \frac{Q^2}{2gA} \times \sqrt{\frac{A^2}{B^2} + \frac{A^2}{C^2} + \frac{A^2}{D^2}} - 2$; which shows that the head of water necessary for producing the discharge increases in the proportion of the square of the quantity of water which is discharged. Pump.

To determine the motion of water in the sucking pump.

These things being premised, it is an easy matter to determine the motion of water in a pump, and the quantity discharged, resulting from the action of any force on the piston, or the force which must be applied to the piston in order to produce any required motion or quantity discharged. We have only to suppose that the force employed is the pressure of a column of water of the diameter of the working barrel; and this is over and above the force which is necessary for merely supporting the water at the height of the place of delivery. The motion of the water will be the same in both cases.

Let us, first of all, consider a sucking pump. The motion here depends on the pressure of the air, and will be the same as if the pump were lying horizontally, and communicated with a reservoir in which is a head of water sufficient to overcome all the obstructions to the motion, and produce a velocity of efflux such as we desire. And here it must be noted that there is a limit. No velocity of the piston can make the water rise in the suction-pipe with a greater velocity than what would be produced by the pressure of a column of water thirty-three feet high; that is, about forty-six feet per second.

Let the velocity of the piston be V, and the area of the working barrel be A. Then, if the water fills the barrel as fast as the piston is drawn up, the discharge during the rise of the piston, or the number of cubic feet of water per second, must be $= V \times A$. This is always supposed, and we have already ascertained the circumstances which insure this to happen. If, therefore, the water arrived with perfect freedom to the piston, the force necessary for giving it this velocity, or for discharging the quantity $V \times A$ in a second, would be equal to the weight of the pillar of water whose height is $\frac{V^2}{2g}$, and base A.

It does not appear at first sight that the force necessary for producing this discharge has any thing to do with the obstructions to the ascent of the water into the pump, because this is produced by the pressure of the atmosphere; and it is the action of this pressure which is measured by the head of water necessary for producing the internal motion in the pump. But we must always recollect that the piston, before bringing up any water, and supporting it at a certain height, was pressed on both sides by the atmosphere. While the air supports the column below the piston, all the pressure expended in this support is abstracted from its pressure on the under part of the piston, while its upper part still supports the whole pressure. The atmosphere continues to press on the under surface of the piston, through the intermedium of the water in the suction-pipe, with the difference of these two forces. Now, while the piston is drawn up with the velocity V, more of the atmospheric pressure must be expended in causing the water to follow the piston; and it is only with the remainder of its whole pressure that it continues to press on the under surface of the piston. Therefore, in order that the piston may be raised with the velocity V, a force must be applied to it, over and above the force necessary for merely supporting the column of water, equal to that part of the atmospheric pressure thus employed; that is, equal to the weight of the head of water necessary for forcing the water up through the suction-pipe, and producing the velocity V in the working barrel.

Therefore let B be the area of the mouth of the suction-

Pump. pipe, and C the area of the fixed valve, and let the suction-pipe be of equal diameter with the working barrel. The head necessary for producing the velocity V on the working barrel is $\frac{V^2}{2g}\left(\frac{A^2}{B^2}+\frac{A^2}{C^2}-1\right)$. If d express the density of water, that is, if d be the number of pounds in a cubic foot of water, then $dA\frac{V^2}{2g}$ will express the weight of a column whose base is A, and height $\frac{V^2}{2g}$, all being reckoned in feet. Therefore the force which must be applied, when estimated in pounds, will be $p=\frac{dAV^2}{2g}\left(\frac{A^2}{B^2}+\frac{A^2}{C^2}-1\right)$.

The first general observation to be made on what has been said is, that the power which must be employed to produce the necessary motion, in opposition to all the obstacles, is in the proportion of the square of the velocity which we would produce, or the square of the quantity of water we would discharge.

We have hitherto proceeded on the supposition that there is no contraction of the jet in passing through these two orifices. This we know would be very far from the truth. We must therefore accommodate things to these circumstances, by diminishing B and C in the ratio of the contraction, and calling the diminished areas b and c; then we have $p=\frac{AdV^2}{2g}\left(\frac{A^2}{b^2}+\frac{A^2}{c^2}-1\right)$.

What this diminution may be, depends on the form of the parts. If the fixed valve and the entry into the pump are simply holes in thin plates, then $b=\frac{62}{100}$ B, and $c=\frac{62}{100}$ C. The entry is commonly widened or trumpet-shaped, which diminishes greatly the contraction; but there are other obstacles in the way, arising from the strainer usually put round it to keep out filth. The valve may have its contraction greatly diminished also by its box being made bell-shaped internally; nay, even giving it a cylindrical box, in the manner of fig. 33, is better than no box at all, as in fig. 5; for such a cylindrical box will have the unaccountable effect of the short tube, and make $b=\frac{82}{100}$ B, instead of $\frac{62}{100}$ B. Thus we see that circumstances seemingly very trifling may produce great effects in the performance of a pump. We should have observed that the valve itself presents an obstacle which diminishes the motion, and requires an increase of power; and it would seem that in this respect the clack or butterfly valve is preferable to the button valve.

Example. Suppose the velocity of the piston to be 2 feet or 24 inches per second, and that the two contracted areas are each one fifth of the area of the pump, which is not much less than what obtains in ordinary pumps. We have $\frac{V^2}{2g}\left(\frac{A^2}{b^2}+\frac{A^2}{c^2}-1\right)=\frac{576}{768}(25+25-1)=36{\cdot}75$ inches, and the force which we must add to what will merely support the column is the weight of a pillar of water incumbent on the piston, and something more than three feet high. This would be a sensible portion of the whole force in raising water to small heights.

We have supposed the suction-pipe to be of the same diameter with the working barrel; but it is usual to make it of smaller diameter, generally equal to the water-way of the fixed valve. This makes a considerable change in the force necessary to be applied to the piston. Let a be the area of the suction-pipe, the area of the entry being still B, and the equivalent entry without contraction being still b; we have the velocity at the entrance $=\frac{AV}{b}$, and the producing head of water $=\frac{A^2V^2}{2g\,b^2}$. After this the velocity is changed to $\frac{AV}{a}$ in the suction-pipe, with which the water Pump. arrives at the valve, where it is again changed to $\frac{AV}{c}$, and requires for this change a head of water equal to $\frac{A^2\,V^2}{2g\,c^2}$. But the velocity retained in the suction-pipe is equivalent to the effect of a head of water $\frac{A^2V^2}{2g\,a^2}$. Therefore the head necessary for producing such a current through the fixed valve that the water may follow the piston with the velocity V, is $\frac{A^2\,V^2}{2g\,b^2}+\frac{A^2\,V^2}{2g\,c^2}-\frac{A^2\,V^2}{2g\,a^2}$, or $=\frac{V^2}{2g}\left(\frac{A^2}{2g}+\frac{A^2}{c^2}-\frac{A^2}{a^2}\right)$. This is evidently less than before, because a is less than A, and therefore $\frac{A^2}{a^2}$ is greater than unity, which was the last term of the former formula. There is some advantage, therefore, derived from making the diameter of the suction-pipe less than that of the working barrel; but this is only because the passage of the fixed valve is smaller, and the inspection of the formula plainly points out that the area of the suction-pipe should be equal to that of the fixed valve. When it is larger, the water must be accelerated in its passage through the valve; which is an useless expense of force, because this velocity is to be immediately reduced to V in the working barrel. If the foregoing example be computed with a equal to one fourth of A, we shall find the head H equal to 29 inches instead of 37.

But this advantage of a smaller suction-pipe is in all cases very moderate; and the pump is always inferior to one of uniform dimensions throughout, having the orifice at the fixed valve of the same area. And if these orifices are considerably diminished in any proportion, the head necessary for overcoming the obstacles, so that the required velocity V may still be produced in the working barrel, is greatly increased. If we suppose the area a one ninth of A, which is frequently done in house-pumps, where the diameter of the suction-pipe does seldom exceed one third of that of the working barrel; and suppose everything made in proportion to this, which is also usual, because the unskilled pump-makers study a symmetry which satisfies the eye; we shall find that the pump taken as an example will require a head of water equal to thirteen feet and upwards. Besides, it must be observed that the friction of the suction-pipe itself has not been taken into the account. This alone is greater, in most cases, than all the obstructions we have been speaking of; for if this pipe is three inches diameter, and that of the working barrel is six, which is reckoned a liberal allowance for a suction-pipe, and if the fixed valve is twenty-five feet above the surface of the pit-water, the friction of this pipe will amount to one third of the whole propelling force.

Thus we have enabled the reader to ascertain the force necessary for producing any required discharge of water from a pump of known dimensions; and the converse of this determination gives us the discharge which will be produced by any given force. For, making $\frac{A^2}{b^2}+\frac{A^2}{c^2}-\frac{A^2}{a^2}$ (which is a known quantity, resulting from the dimensions of the pump) $=$ M, we have $H=\frac{V^2}{2g}M$, and $V^2=\frac{2g\,H}{M}$, and $V=\sqrt{\frac{2g\,H}{M}}$. Now H is that part of the natural power which we have at command which exceeds what is necessary for merely supporting the column of water. Thus, if

Pump. we have a pump whose piston has an area of one fourth of a square foot, its diameter being six and three-fourth inches; and we have to raise the water thirty-two feet, and can apply a power of five hundred and twenty-five pounds to the piston; we wish to know at what rate the piston will be moved, and the quantity of water discharged. Merely to support the column of water of this height and diameter, requires five hundred pounds. Therefore the remaining power, which is to produce the motion, is twenty-five pounds. This is the weight of a column one foot four inches high, and H = 1333 feet. Let us suppose the diameter of the suction-pipe one half of that of the working barrel, so that $\frac{A}{B} = 4$. We may suppose it executed in the best manner, having its lower extremity trumpet-shaped, formed by the revolution of the proper trochoid. The contraction at the entry may therefore be considered as nothing, and $\frac{A}{b} = 4$, and $\frac{A^2}{b^2} = 16$. We may also suppose the orifice of the fixed valve equal to the area of the suction-pipe, so that $\frac{A^2}{C^2}$ is also = 16; and there is no contraction here, and therefore $\frac{A^2}{c^2}$ is also 16; and, lastly, $\frac{A^2}{a^2}$ is also 16. Therefore $\frac{A^2}{b^2} + \frac{A^2}{c^2} - \frac{A^2}{a^2}$ or M, = 16 + 16 — 16, = 16. We have also $2g = 64$. Now $N = \sqrt{\frac{2g\,H}{M}}, = \sqrt{\frac{64 \times 1333}{16}}, = 2309$ feet, and the piston will move with the velocity of two feet four inches nearly. Its velocity will be less than this, on account both of the friction of the piston and the friction of the water in the suction-pipe. These two circumstances will probably reduce it to one foot eight inches; and it can hardly be less than this.

We have taken no notice of the friction of the water in the working barrel, or in the space above the piston; because it is in all cases quite insignificant. The longest pipes employed in our deep mines do not require more than a few inches of head to overcome it.

But there is another circumstance which must not be omitted. This is the resistance given to the piston in its descent. The pistons of an engine for drawing water from deep mines must descend again by their own weight in order to repeat their stroke. This must require a preponderance on that end of the working beam to which they are attached, and this must be overcome by the moving power during the effective stroke. It makes, therefore, part of the whole work to be done, and must be added to the weight of the column of water which must be raised.

This is very easily ascertained. Let the velocity of the piston in its descent be V, the area of the pump-barrel A, and the area of the piston-valve *a*. It is evident, that while the piston descends with the velocity V, the water which is displaced by the piston in a second is (A—*a*) V. This must pass through the hole of the piston, in order to occupy the space above, which is left by the piston. If there were no contraction the water would go through with the velocity $\frac{A-a}{a}$ V; but as there will always be some contraction, let the diminished area of the hole (to be discovered by experiment) be *b*; the velocity therefore will be $V\frac{A-a}{b}$. This requires for its production a head of water $\frac{V^2}{2g}\left(\frac{A-a}{b}\right)^2$. This is the height of a column of water the base of which is not A, but A—*a*. Calling the density of water *d*, we have for the weight of this column, and the force *p* in $d \times \overline{A-a} + \left(\frac{A-a}{b}\right) \times \frac{V^2}{2g}, = \frac{dV^2(A-a)^3}{2gb^2}$. This, we see again, is proportional to the square of the velocity of the piston in its descent, and has no relation to the height to which the water is raised. Pump.

If the piston has a button-valve, its surface is at least equal to *a*; and therefore the pressure is exerted on the water by the whole surface of the piston. In this case we shall have $p = \frac{dV^2A^3}{2gb2}$, considerably greater than before. We cannot ascertain this value with great precision, because it is extremely difficult, if possible, to determine the resistance in so complicated a case. But the formula is exact if *b* can be given exactly; and we know within very moderate limits what it may amount to. In a pump of the very best construction. with a button-valve, *b* cannot exceed one half of A; and therefore $\frac{A^3}{b^2}$ cannot be less than 8. In this case, $\frac{V^2\,A^3}{2g\,b^2}$ will be $\frac{V^2}{8}$. In a good steam-engine pump, V is about three feet per second, and $\frac{V^2}{8}$ is about $1\frac{1}{8}$ feet, which is but a small matter.

We have hitherto been considering the sucking pump alone; but the forcing pump is of more importance, and apparently more difficult of investigation. Here we have to overcome the obstructions in long pipes, with many bends, contractions, and other obstructions. But the consideration of what relates merely to the pump is abundantly simple. In most cases we have only to force the water into an air-vessel, in opposition to the elasticity of the air compressed in it, and to send it thither with a certain velocity, regulated by the quantity of water discharged in a given time. The elasticity of the air in the air-vessel propels it along the main. We are not now speaking of the force necessary for counterbalancing this pressure of the air in the air-vessel, which is equivalent to all the subsequent obstructions, but only of the force necessary for propelling the water out of the pump with the proper velocity. Motion of water in the forcing pump.

We have in a manner determined this already. The piston is solid, and the water which it forces has to pass through a valve in the lateral pipe, and then to move in the direction of the main. The change of direction requires an addition of force to what is necessary for merely impelling the water through the valve. Its quantity is not easily determined by any theory, and it varies according to the abruptness of the turn. It appears from experiment, that when a pipe is bent to a right angle, without any curvature or rounding, the velocity is diminished about $\frac{1}{18}$th. This would augment the head of water $\frac{1}{9}$th. This may be added to the contraction of the valve hole. Let *c* be its natural area, and, whatever is the contraction competent to its form, increase it $\frac{1}{18}$th, and call the contracted area *c*. Then this will require a head of water $= \frac{V^2\,A^2}{2g\,c^2}$. This must be added to the head $\frac{V^2}{2g}$, necessary for merely giving the velocity V to the water. Therefore the whole is $\frac{V^2}{2g}\left(\frac{A^2}{c^2} + 1\right)$; and the power *p* necessary for this purpose is $\frac{d\,AV^2}{2g}\left(\frac{A^2}{c^2} + 1\right)$.

It cannot escape the observation of the reader, that in all these formulæ, expressing the height of the column of water which would produce the velocity V in the working barrel of the pump, the quantity which multiplies the con-

Pun.

stant factor $\frac{d\,AV^2}{2\,g}$ depends on the contracted passages which are in different parts of the pump, and increases in the duplicate proportion of the sum of those contractions. It is therefore of the utmost consequence to avoid all such, and to make the main which leads from the forcing pump equal to the working barrel. If it be only of half the diameter, it has but one fourth of the area, the velocity in the main is four times greater than that of the piston, and the force necessary for discharging the same quantity of water is sixteen times greater.

Use of experiments.

It is not, however, possible to avoid these contractions altogether, without making the main pipe wider than the barrel. For if only so wide, with an entry of the same size, the valve makes a considerable obstruction. Unskilful engineers endeavour to obviate this by making an enlargement in that part of the main which contains the valve. This is seen in fig. 14, at the valve L. If this be not done with great judgment, it will increase the obstructions. For if this enlargement is full of water, the water must move in the direction of its axis with a diminished velocity; and when it comes into the main, it must again be accelerated. In short, any abrupt enlargement which is to be afterwards contracted does as much harm as a contraction, unless it be so short that the water in the axis keeps its velocity till it reaches the contraction. Nothing would do more service to an artist who is not well founded in the theory of hydrodynamics, than to make a few simple and cheap experiments with a vessel like that of fig. 37. Let the horizontal pipe be about three inches diameter, and made in joints which can be added to each other. Let the joints be about six inches long, and the holes from one fourth to a whole inch in diameter. Fill the vessel with water, and observe the time of its sinking three or four inches. Each joint should have a small hole in its upper side to let out the air; and when the water runs out by it, let it be stopped by a peg. He will see that the larger the pipe is in proportion to the orifices made in the partitions, the efflux is more diminished. We believe that no person would suspect this who has not considered the subject minutely.

All angular enlargements, all boxes into which the pipes from different working barrels unite their water before it goes into a main, must therefore be avoided by an artist who would execute a good machine; and the different contractions which are unavoidable at the seats of valves and the perforations of pistons, &c. should be diminished by giving the parts a trumpet-shape.

In the air-vessels represented in fig. 13, this is of very great consequence. The throat O, through which the water is forced by the expansion of the confined air, should always be formed in this manner. For it is this which produces the motion during the returning part of the stroke in the pump constructed like fig. 13, No. 1, and during the whole stroke in No. 2. Neglecting this seemingly trifling circumstance will diminish the performance at least one fifth. The construction of No. 1 is the best, for it is hardly possible to make the passage of the other so free from the effects of contraction. The motion of the water during the returning stroke is very much contorted.

Punch.

Accelerated motion of water in pumps.

There is one circumstance that we have not taken any notice of, viz. the gradual acceleration of the motion of water in pumps. When a force is applied to the piston, it does not in an instant communicate all the velocity which it acquires. It acts as gravity acts on heavy bodies; and if the resistances remained the same, it would produce, like gravity, an uniformly accelerated motion. But we have seen that the resistances, which are always measured by the force that just overcomes them, increase as the square of the velocity increases. They therefore quickly balance the action of the moving power, and the motion becomes uniform in a time so short that we commit no error of any consequence by supposing it uniform from the beginning. It would have prodigiously embarrassed our investigations to introduce this circumstance; and it is a matter of mere speculative curiosity; for most of our moving powers are unequal in their exertions, and these exertions are regulated by other laws. The pressure on a piston moved by a crank is as variable as its velocity, and in most cases is nearly in the inverse proportion of its velocity, as any mechanician will readily discover. The only case in which we could consider this matter with any degree of comprehensibility is that of a steam-engine, or of a piston which forces by means of a weight lying on it. In both, the velocity becomes uniform in a very small fraction of a second.

Deficiency of elementary books on this subject.

We have been very minute on this subject. For although it is the only view of a pump which is of any importance, it is hardly ever understood even by professed engineers; and this is not peculiar to hydraulics, but is seen in all the branches of practical mechanics. The elementary knowledge to be met with in such books as are generally perused by them, goes no farther than to state the forces which are in equilibrio by the intervention of a machine, or the proportion of the parts of a machine which will set two known forces in equilibrio. But when this equilibrium is destroyed by the superiority of one of the forces, the machine must move; and the only interesting question is, what will be the motion? Till this is answered with some precision, we have learned nothing of any importance. Few engineers are able to answer this question even in the simplest cases; and they cannot, from any confident science, say what will be the performance of an untried machine. They guess at it with a success proportioned to the multiplicity of their experience and their own sagacity. Yet this part of mechanics is as susceptible of accurate computation as the cases of equilibrium. We therefore thought it our duty to point out the manner of proceeding so circumstantially that every step should be plain and easy, and that conviction should always accompany our progress. This we think it has been in our power to do, by the very simple method of substituting a column of water acting by its weight in lieu of any natural power which we may chance to employ.

To such as wish to prosecute the study of this important part of hydraulics in its most abstruse parts, we recommend the perusal of the Dissertations of M. Pitot and M. Bossut, in the Memoirs of the Academy of Paris; the Dissertations of the Chevalier de la Borda, 1766 and 1767; and the *Hydraulique* of the Chevalier de Buat.

PUN, an expression where a word has at once different meanings. The practice of punning is the refuge of those who wish to pass for wits, without having a grain of it in their composition. James I. of England delighted in punning; and the taste of the sovereign was studied by the courtiers, nay, even by the clergy. Hence the sermons of that age abound with this species of false wit. It continued to be more or less fashionable until the reign of Queen Anne, when Addison, Swift, Pope, and Arbuthnot, with the other real wits of that age, united their efforts to banish punning from polite composition. It is still admitted sparingly in conversation, and only from those who cannot furnish anything better.

PUNCH, an instrument of iron or steel, used in several arts, for piercing or stamping holes in plates of metals, and other purposes, being so contrived as not only to perforate, but to cut out and take away the piece. The punch is a principal instrument of the metal-button makers, shoemakers, and other craftsmen.

PUNCH is also a name for a sort of compound drink, much

Puncheon ‖ Punctuation.

used in this country, and in many parts abroad, particularly in Jamaica, and several other parts of the West Indies.

PUNCHEON, Punchin, or *Punchion*, a little block or piece of steel, on one end of which is some figure, letter, or mark, engraved either *en creux* or in relief, and impressions of which are taken on metal or some other matter, by striking it with a hammer on the end not engraved. There are various kinds of these puncheons used in the mechanical arts; such, for instance, are those of the goldsmiths, cutlers, pewterers, and others.

The puncheon, in coining, is a piece of iron steeled, on which the engraver has cut in relief the several figures, arms, effigy, inscription, or the like, that there are to be in the matrices wherewith the species are to be marked. Minters distinguish three kinds of puncheons, according to the three kinds of matrices to be made; that of the effigy, that of the cross or arms, and that of the legend or inscription. The first includes the whole portrait in relief; the second is small, containing only a piece of the cross or arms, as a fleur-de-lis, a harp, or a coronet, by the assemblage of all which the entire matrice is formed; the puncheons of the legend contain only one letter each, and serve equally for the legend on the effigy side and the cross side. (See the article Coinage.)

Puncheon is also the name of several iron tools, of various sizes and figures, used by the engravers *en creux* on metals. Seal-engravers particularly use a great number for the several pieces of arms, and other devices to be engraven, and many stamp the whole seal from a single puncheon.

Puncheon is also a common name for all the iron instruments used by stone-cutters, sculptors, blacksmiths, and others, for the cutting, inciding, or piercing their several matters.

Those of sculptors and statuaries serve for the repairing of statues when taken out of the moulds. The locksmiths use the greatest variety of puncheons; some for piercing hot, others for piercing cold; some flat, others square; some round, others oval; each to pierce holes of its respective figure in the several parts of locks.

Puncheon, in *Carpentry*, is a piece of timber placed upright between two posts, the bearing of which is too great, and serving, together with them, to sustain some large weights.

Puncheon is also the name of a measure for liquids, containing about a hundred and thirty-three gallons.

PUNCTUATION, in *Grammar*, the art of pointing, or of dividing a discourse into periods, by points expressing the pauses to be made therein.

The points used are four; the period, colon, semicolon, and comma, which are too well known to require any particular explanation. We shall only observe, in general, therefore, that the comma is used to distinguish nouns from nouns, verbs from verbs, and such other parts of a period as are not necessarily joined together. The semicolon serves to suspend and sustain the period when too long; the colon to add some new or supernumerary reason or consequence to what is already said; and the period to close up the sense and construction, and release the voice.

It has been asserted, that punctuation is a modern art, and that the ancients were entirely unacquainted with the use of our commas and other points, and wrote not only without any distinction of numbers and periods, but also without distinction of words; a custom which, Lipsius observes, continued until the hundred and fourth Olympiad, during which time the sense alone divided the discourse.

What places this beyond dispute is the Alexandrian manuscript, in the British Museum. Whoever examines this codex will find that the whole is written *continuo ductu*, without distinction of words or sentences. How the ancients read their works written in this manner, it is not easy to conceive.

Punctuation.

After the practice ceased of joining words together, notes of distinction were placed at the end of every word. In all the editions of the *Fasti Capitolini* these points occur. The same are to be seen on the *Columna Rostrata*. For want of them, we find much confusion in the *Chronicon Marmoreum*, and the covenant between the Smyrnæans and Magnesians, which are both at Oxford. In Salmasius's edition of *Dedicatio Statuæ Rigillæ Herodis*, the same confusion occurs, where we find ΔΕΥΡΙΤΕ and Δευρ ισι.

Of these marks of distinction, the Walcote inscription found near Bath may serve as a specimen;

IVLIUSv VITALISv FABRI
CESISv LEGv XXVv Vv V
STIPENDIORUMv

After every word here, except at the end of a line, we see the mark v. There is an inscription in Montfaucon, which has a capital letter laid in an horizontal position, by way of interstitial mark, which makes one apt to think that this way of pointing was sometimes according to the fancy of the graver.

P. FERRARIVS HERMES
CAECINIAE ⊣ DIGNAE
CONIVGI ⊣ KARISSIMAE
NVMERIAE ⊣

Here we observe after the words a T laid horizontally, but not after each word, which proves this to be of a much later age than the former.

As the improvement of stops appears not to have taken place whilst manuscripts and monumental inscriptions were the only known methods of conveying knowledge, it is conjectured that it was introduced with the art of printing. The fourteenth century, to which we are supposed to be indebted for this invention, did not, however, bestow those appendages which we call *stops*. Whoever will be at the pains of examining the first printed books, will discover no stops of any kind; but arbitrary marks here and there, according to the humour of the printer. In the sixteenth century we observe their first appearance. From the books of this age, we find that they were not at all produced at the same time; those we meet with in use being only the comma, the parenthesis, the interrogation, and the full point. To prove this, we need but look into Bale's Acts of English Worthies, in black letter, printed in 1550. In the dedication of this book to Edward VI. we discover a colon, it is true; but as this is the only one of the kind throughout the work, it is plain that the colon was not established at that time, or, if it was, that it had not yet come into common use. Thirty years afterwards, in the sensible and judicious performance of Sir Thomas Elyot, entitled The Governour, imprinted in the year 1580, we see the colon as frequently introduced as any other stop; but the semicolon and the mark of admiration were still wanting, neither of these being visible in Sir Thomas's book. In Hackluyt's Voyages, printed in 1599, we meet with the semicolon; but, as if the editors did not fully apprehend the propriety of its general admission, it is sparingly introduced. It has been said, indeed, that the semicolon was brought into use at a much earlier period; but it appears that it was only for the purpose of an abbreviation, as in (*namq ;*) (*neq ;*) for *namque*, *neque*, and not in the sense in which it is now employed.

The semicolon, as well as all the ordinary points, is used in a work entitled *Imagines Deorum*, printed at Leyden in the year 1581, in Roman characters. We likewise meet with them in the translation of a book written in French by Philip de Mornay, lord of Plessis; in the Schoolmaster of Roger Ascham, printed in 1570, with the exception of the semicolon; and in the Trewnesse of the Christian Religion, by Sir Philip Sidney, published in 1587, in which we find the asterisk, brackets, the interrogation, the comma, and the semicolon, all as we now use them, the colon and period being square dots.

Punctuation.

In an alchemical manuscript, of date 1572, the semicolon is said to be met with, as well as the other three points which are now in common use. The colon and period are abundant in a work entitled *Dionysius de Situ Orbis*, printed at Venice in 1498, but none of the other stops or points occur. The single point (.) appears to be the most ancient. Since the year 1485 the colon was introduced; the comma is first seen about the year 1521; and the more refined semicolon was brought into use about the year 1570.

The invention of the semicolon is most probably due to the English; for, from the Leyden edition of Pliny, 1553, it is evident that the Dutch printers were not then in the practice of using it; and if they were in 1570, Roger Ascham would probably have employed it, since the Dutch were the principal classical printers in his time. But we find that some English books were marked with it at that period.

The note of admiration was the last stop invented, and seems to have been added to the rest at a period not far distant from our own time.

Thus we see that these notes of distinction came into use as learning gradually advanced and improved; one invention, indeed, but enlarged by several additions. But notwithstanding what has been said relative to the use of stops as being a modern invention, we shall find reason to be satisfied that the ancients were not unacquainted with the method of making pauses in speaking and writing, if we attend to the following investigation of Warburton.

"Some species of pauses and divisions of sentences in speaking and writing must have been coeval with the knowledge of communicating ideas by sound or by symbols.

"Suidas says that the *period* and the *colon* were discovered and explained by Thrasymachus, about 380 years before the Christian era. Cicero says that Thrasymachus was the first who studied oratorical numbers, which entirely consisted in the artificial structure of periods and colons. It appears from a passage in Aristotle, that punctuation was known in his time. The learned Dr Edward Bernard refers the knowledge of pointing to the time of that philosopher, and says that it consisted in the different positions of one single point. At the bottom of a letter, thus (A.), it was equivalent to a comma; in the middle (A·) it was equal to a colon; at the top (A˙) it denoted a period, or the conclusion of a sentence.

"This mode was easily practised in Greek manuscripts, while they were written in capitals. But when the small letters were adopted, that is, about the ninth century, this distinction could not be observed; a change was therefore made in the scheme of punctuation. *Unciales literas hodierno usu dicimus eas in vetustis codicibus, quæ priscam formam servant, ac solutæ sunt, nec mutuo colligantur. Hujus modi literæ unciales observantur in libris omnibus ad nonum usque sæculum.* Montf. *Palæog. Recens.* p. xii.

"According to Cicero, the ancient Romans as well as the Greeks made use of points. He mentions these under the appellation of *librariorum notæ;* and in several parts of his works he speaks of '*interpunctæ clausulæ in orationibus.*'

"Seneca, who died A. D. 65, expressly says that Latin writers in his time had been used to punctuation. '*Nos, cum scribimus, interpungere consuevimus.*' Muretus and Lipsius imagined that these words alluded to the insertion of a point after each word; but they certainly were mistaken, for they must necessarily refer to marks of punctuation in the division of sentences, because in the passage in which these words occur, Seneca is speaking of one Q. Haterius, who made no pauses in his orations.

"According to Suetonius, Valerius Probus procured copies of many old books, and employed himself in correcting, pointing, and illustrating them; devoting his time to this and no other part of grammar: *Multa exemplaria contracta emendare, ac distinguere et adnotare curavit; soli huic, nec ulli præterea, grammatices parti deditus.* It appears from hence that, in the time of Probus, or about the year 68, Latin manuscripts had not been usually pointed, and that grammarians made it their business to supply this deficiency. Quintillian, who wrote his celebrated treatise on Oratory about the year 88, speaks of commas, colons, and periods; but it must be observed that by these terms he means clauses, members, and complete sentences, and not the marks of punctuation. Ælius Donatus published a treatise on Grammar in the fourth century, in which he explains the *distinctio*, the *media distinctio*, and the *subdistinctio;* that is, the use of a single point in the various positions already mentioned.

Punctum Saliens || Punganoor.

"Jerome, who had been the pupil of Donatus, in his Latin version of the Scriptures made use of certain distinctions or divisions, which he calls *cola* and *commata*. It has however been thought probable that these divisions were not made by the addition of any points or stops, but were formed by writing, in one line, as many words as constituted a clause, equivalent to what we distinguish by a comma or a colon. These divisions were called στιχοι or ρημαται, and had the appearance of short irregular verses in poetry. There are some Greek manuscripts still extant which are written in this manner."

PUNCTUM SALIENS, in *Anatomy*, the first rudiments of the heart in the formation of the fœtus, where a throbbing motion is perceived.

PUNCTUM *Stans*, a phrase by which the schoolmen vainly attempt to bring within the reach of human comprehension the positive eternity of God. Those subtile reasoners seem to have discovered that nothing which is made up of parts, whether continuous or discrete, can be absolutely infinite, and that therefore eternity cannot consist of a boundless series of successive moments. Yet, as if such a series had always existed, and were commensurate in duration with the Supreme Being, they compared his eternity to one of the moments which compose the flux of time arrested in its course; and to this eternal moment they gave the name of *punctum stans*, because it was supposed to stand still, whilst the rest followed each other in succession, all vanishing as soon as they appeared.

PUNDA, or PUNDY, a town of Hindustan, province of Bejapore, twenty-five miles south-east from Goa, and near the south-west extremity of the territories belonging to the Poonah Mahrattas. Long. 74. 3. E. Lat. 15. 20. N. There is another place of the same name in the Northern Circars. Long. 84. 40. E. Lat. 18. 43. N.

PUNDERPOOR, or PUNDEPORE, a town of Hindustan, in the province of Bejapore, situated on the left bank of the river Beemal. It is not very large, but is a prosperous and populous place. The streets are broad and well paved, and adorned with very handsome houses, almost all the principal members of the Mahratta empire having dwellings there, where they spend some months of every year, when they are not engaged in hostilities with each other, or with some foreign power. It has an extensive market, well supplied not only with grain, cloth, and the productions of the country, but with many articles of English manufacture. There is also a handsome temple dedicated to Vishnu, which is regarded as of peculiar sanctity. The surrounding country is well wooded and watered, and near the town the soil is good. It is eighty-six miles south-east from Poonah. Long. 75. 12. E. Lat. 17. 56. N.

PUNDUAH, or PURRUAH, a town of Bengal, and for a short period the capital of that province, but now in ruins. Long. 88. 9. E. Lat. 25. 9. N.

PUNGANOOR, a fortified town of Hindustan, in the province of Golcondah, and district of Balaghaut, ceded to the British by the nizam in 1799, and dependent on Madras. It is a hundred and seventeen miles west by north from Madras. Long. 78. 42. E. Lat. 13. 19. N.

PUNISHMENT

Punishment.

In noticing the present state of the science of penal law, the course we shall adopt, as best suited to the narrow space within which our observations must be confined, is, in the first place, to give an outline of the theory of punishment, according to the opinions of some distinguished modern writers, and afterwards to offer a sketch of the progress which penal legislation has recently made, as well on the Continent as in Great Britain.

Slow progress of jurisprudence.

Experience abundantly proves, that the establishment of a tolerably good, much less of a perfect system of law, whether civil or criminal, is a very slow and difficult operation. Criminal law everywhere begins, where, amongst savages, it continues and ends, with the pursuit and gratification of the passion of revenge. Injuries, or presumed injuries, are punished according to the will and power of the injured, whose might, in truth, constitutes their right. The first step in civilization is the social union for the protection of every member of it from injury, by the exercise of the aggregate power of the whole in his defence. But in some countries ages have elapsed before, and in others it has never come to pass, that any comprehensive view is taken of penal jurisprudence, so as to enumerate and classify offences, and to annex to them the punishments best adapted to prevent their recurrence. Unless the public feeling is outraged by some glaring enormity, the mass of the people concern themselves little with the relations existing between crimes and punishments; and it is only by opening upon a nation the lights of reason and philosophy, that it can be brought to appreciate the blessing of a wise and just criminal code. It is the task of the philosopher to direct the opinion of the multitude in the direction of truth and justice; nor is it possible to estimate too highly the benefits which mankind are deriving from the wisdom which has been bequeathed to them by a Montesquieu, a Filangieri, a Beccaria, or a Bentham.[1]

Theory of Beccaria.

The Marquis of Beccaria's well-known treatise, *De' Delitti e Delle Pene*, has acquired a great and deserved celebrity.[2] That remarkable man was the first to promulgate to Europe the outlines of a system of jurisprudence founded upon the principle of "the greatest happiness of the greatest number." Assuming the general utility to be the only legitimate object of law, Beccaria professes to inquire, What is the origin of punishments, and what is the foundation of the right to punish? What are the practicable means, under a good legislation, of seizing the criminal, and of discovering and ascertaining the crime? Is torturing the criminal just, and does it lead to the end proposed by the laws? Ought not punishments to be proportioned to crimes, and how is this proportion to be established? What is the measure of the gravity of crimes? Is the punishment of death useful and necessary for the security and good order of society? What punishments ought to be inflicted on different crimes? Are the same punishments equally useful at all times? What influence have they upon manners? What are the most efficacious means of preventing crimes? In offering solutions of these problems, Beccaria proclaims, in the outset, that political morality, of which punishment is a part, ought to be founded upon the permanent sentiments of the human heart, and that the right to punish is derived from the social contract, wherein every individual has surrendered to the society so much of his liberty as the necessities of the whole require him to sacrifice, and no more. Every exercise of power, every punishment, is an abuse of justice, unless it is necessary for the preservation of the common deposit of public liberty. Three consequences follow: first, that it belongs to law alone, as the condition of the social contract, to award punishment to crime; secondly, that it is the province of the judge, not of the sovereign power, to determine the fact of the violation of the law; thirdly, that the inutility of a punishment is sufficient to constitute its injustice, as contrary to the social contract. In regard to the gravity of punishment, Beccaria held that it should be relative to the actual circumstances of a nation, because it may be requisite to awe more strongly the minds of a people recently elapsed from barbarism than those of a people whose sensibilities have been softened by the influence of civilization. The punishment of death is declared not to be authorized by any right belonging to society, but to be rather the act of the nation making war against a citizen whose destruction is regarded as useful and necessary to the society's preservation. An extreme case may arise, in times of national troubles, when the death of a citizen may be justifiable by necessity, but never under the ordinary and tranquil reign of the law. In other words, it is only when necessary, in the strictest sense, that capital punishment is just. Punishment should be prompt, because the less time that intervenes between it and the offence, the closer and stronger will be the association of ideas, so that the punishment will be regarded as the effect of the crime. It should also be analogous to the crime; should be public; and, above all, certain and inevitable, subject to the rare exercise of the prerogative of mercy. A due proportion must exist between crimes and their punishments; and if mathematical calculations could be rendered applicable to the infinite and obscure combinations of human actions, there should be a progressive scale of punishments, corresponding with all crimes, from the gravest down to the lightest. Beccaria divides crimes into three classes: viz. those destructive to society; those which attack the citizen in life, wealth, or honour; and those which are generally injurious to the public welfare. In his judgment, the way to prevent duels is to punish the aggressor who gives the first provocation; thefts are to be corrected by fine, or compensative labour; and suicide is not to be regarded as a crime in the sight of men. Such are some of the ideas promulgated by Beccaria, as flowing from the principle, that public utility is the only solid basis of human justice. We shall presently see, that this principle has by no means obtained the general assent of jurists; but the views of Beccaria are throughout consistent and luminous, and were extraordinarily in advance of the age in which he lived. The following general theorem is given as the conclusion of his essay: In order that a punishment should not be a violence of one, or of several, against a citizen, it should be public, prompt, necessary, the least possible under given circumstances, proportioned to the offence, and fixed by the law.

Works of Bentham.

It is to our distinguished countryman, Bentham, that belongs the honour of having been the first to travel over the

[1] The first two of these writers not having offered any thing like a regular theory of penal law, it will suffice to refer the reader to their respective works, without more particular notice here.

[2] The translation into French by Morellet, with Diderot's notes, (Paris, 1797), is the preferable edition.

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whole field of penal legislation; to shew the intimate connexion that exists between all its parts; the mutual dependence and relation of the civil and penal codes; and the impossibility of framing either of these portions of law without having previously taken a comprehensive survey of the whole. For the details we must refer to the works themselves, which so completely exhaust the subject, that the theory offered is complete in all its parts. In that portion of the *Traités de Législation Civile et Pénale*, entitled, *Principes du Code Pénale*, and in the later and more comprehensive treatise, entitled, *Théorie des Peines et des Récompenses*, will be found the principles of a complete penal code, laid down with scientific precision, definitions, and classifications.[1] Like Beccaria, Bentham recognized the general utility as the sole object of legislation. A crime or offence, therefore, under his theory, is an act which ought to be prohibited by reason of some evil to which it gives rise, or tends to give rise. Crimes are then divided into four classes, viz:

1st, Private offences.
2d, Self-regarding offences.
3d, Semi-public offences.
4th, Public offences.

And under these four general heads, and the combination of them, all offences may be classed and arranged. These heads are again subdivided, thus:

Private offences are, either against the person, against property, against the reputation, or against the condition in life.

Self-regarding offences may be similarly subdivided, and are enumerated rather to remind the legislator that they are out of his sphere.

Semi-public offences consist in the violation of the laws designed to prevent physical calamities to the inhabitants of a given district, or malicious injuries to particular classes of persons.

Public offences are of nine kinds, viz: against the external security of the state, against justice and police, against the national forces, against the public revenue, against the population and the national wealth, against the sovereign power, and against religion.

The remedies applicable to these offences, and the means, direct and indirect, of preventing their commission, form the subject of the *Principes du Code Pénal.*

The subsequent work *(Théorie des Peines, &c.)* sets out by thus defining legal punishment: "According to the principle of utility, legal punishments are evils inflicted, with judicial forms, on individuals convicted of some hurtful act, forbidden by the law, and in order to prevent similar acts."[2] The same division as that of private offences is then made applicable to punishments, inasmuch as an individual can only be punished by affecting either his person, his property, his reputation, or his condition. Personal or corporal punishments are then subdivided into,

1st, Punishments simply afflictive.
2d, ... afflictive by complication.
3d, ... restrictive.
4th, ... active or laborious.
5th, ... capital.

Those affecting property, reputation, or condition, alike deprive the individual of some advantage which he before enjoyed, and are either privations, losses, or forfeitures. Thus are punishments reduced to two classes; viz. 1st, corporal, and 2d, privative punishments.

According to Bentham, the end of punishment is twofold; to prevent the repetition of similar offences, and to repair, as much as possible, the evil of the offence committed. He lays down the following rules, which serve to explain the general proposition of Beccaria, that a proportion should be established between crimes and punishments, viz: Punishment.

1st, The evil which the person punished is to sustain from the punishment, must exceed the advantage derivable by him from the crime.

2d, When the act is of a nature to furnish a conclusive proof of habitude, the punishment must be severe enough to exceed not only the advantage of the particular offence, but also of all similar offences which may be supposed to have been committed with impunity by the same offender.

3d, The punishment ought to exceed the advantage of the crime to the extent of making up that which the punishment wants in point of certainty and of proximity.

4th, If two or more crimes concur, the most hurtful ought to be subjected to a more severe punishment, in order that the offender may have a motive to stop at the least offence.

5th, The more hurtful a crime, the more may a heavy punishment be hazarded for the chance of preventing it.

6th, The same punishment ought not to be inflicted for the same crime on all offenders without exception. Regard must be had to the circumstances which influence sensibility.

These rules will better serve as a guide to the measure of punishment, than any attempt at the mathematical scale suggested by Beccaria, which seems inapplicable to the infinite varieties of the human mind. An ancient writer has bequeathed us a plainer maxim on this point:

——— adsit
Regula peccatis, quæ pœnas irroget æquas,
Nec scuticâ dignum, horribili sectere flagello.[3]

The qualities enumerated by Bentham as desirable to every mode of punishment, in order that it may answer its proper ends, are these:—

1st, Divisibility; so that it may be susceptible of addition or diminution, either in intensity or duration. Corporal chastisement, hard labour, and imprisonment, are instances of punishments alike possessing this quality.

2d, Certainty. A punishment is uncertain and unequal in itself, when an offender may possibly undergo it, without suffering any evil. Banishment, for example, may be good or evil according to various circumstances.

3d, Commensurability. If death were inflicted on three offences of different degrees of guilt, the punishment would not be commensurate, but would leave to the offender the choice of the crime which might be easiest of execution.

4th, Analogy. There should be some characteristic resemblance between the crime and the punishment. Not exactly "eye for eye, and tooth for tooth," but something to strike the memory and imagination by association.

5th, Exemplarity, so that there be not only the reality, but the appearance of penality; otherwise the effect on the public will be lost.

6th, Economy; viz. that the degree of severity be not greater than the end requires, and also that the public charge be not enhanced more than is necessary.

7th, Remissibility. There should be an opportunity for remission or revocation. Capital punishment is the strongest instance of a deficiency of this quality.

8th, Suppression of the power of injury. It may be possible, under extraordinary circumstances, that death is the only available punishment possessing this quality.

9th, Tendency to moral amendment. If fear alone operates, the criminal will not be reformed. Reformation is a change in the character and moral habits. The association of prisoners is the grand obstacle in the way of imparting this quality to imprisonment.

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[1] We quote from M. Dumont's translations. The first complete edition of Bentham's works in English, is now in the course of publication, under the superintendence of his executor.

[2] Dr. Johnson's definition of punishment was, "any infliction or pain in vengeance of a crime;" that of Grotius, "malum passionis quod infligitur ob malum actionis." The latter is obviously the better of the two.

[3] *Horat* lib. i. sat. 3.

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10th, Convertibility to profit. This quality belongs only to certain kinds of punishments, such as pecuniary fines, or deprivation of employments, which may be conferred on more worthy persons.

11th, Simplicity in description is so obviously desirable as to require no comment.

12th, Popularity; that is to say, that in the choice of punishments, the legislature should carefully avoid such as would shock established prejudices.

The above catalogue will assist the judgment in determining how far a given punishment is desirable; but Bentham adds a caution, that in this as in every inquiry, we should begin by forming an abstract idea of the qualities which an object ought to possess, in order to reason pertinently about it, otherwise approbation or disapprobation is merely a confused sentiment of sympathy or antipathy. It should also be observed, in reference to the catalogue, that regard is to be had not only to one quality in particular, but to all taken together. No mode of punishment unites them all, but, according to the nature of the offences, some are more important than others. Thus, for graver crimes, exemplarity and analogy are especially to be regarded; for lighter offences, economy and reformation; for crimes against property, convertibility to profit, from whence compensation may be derived for the party injured.

To illustrate the applicability of Bentham's penal qualities, let us refer to one or two of the most familiar punishments. Imprisonment, for instance, is very efficacious for suppressing the prisoner's power of doing injury, whilst he continues in custody. It may, or may not be made profitable, according to the mode in which the prisoners are employed; but under the plan of the Panopticon, the profit derivable from the earnings is a leading feature of that establishment. In respect of certainty, or equality, imprisonment is evidently very defective, as the evil of it depends so much upon the age, the health, the habits, and frame of mind of the prisoner. It is divisible, both in time and severity; and is in some sort exemplary, since either the public may be admitted, as proposed in the Panopticon plan, or the sight of the building will strike the imagination with a degree of terror. In point of simplicity of description it is perfect, since all understand what confinement means. In respect of reformation, the effect of imprisonment must depend upon the system of discipline adopted. Bentham stigmatises the association of prisoners in general as pregnant with evil, and as constituting a punishment evidently uncertain, unequal, unexemplary, unprofitable, productive of a variety of suffering, of which no one who has not experienced it, can form a tolerably just idea. The hurtful consequences of such association, which are vaguely expressed by the word *corruption*, are thus defined by Bentham:

1st, The strengthening of the motives which excite to the commission of crimes.

2d, The weakening of the considerations which tend to the repression of crimes.

3d, The instruction acquired in the art of accomplishing crimes.

Bentham's views of what a prison should be are fully developed in his Panopticon, wherein labour is made the main engine of reformation. We have treated this subject more fully in another place, (see article Prisons); but although great advances have been lately made in regard to it, the opinions of Bentham are still full of instruction, and should by no means be lost sight of in determining the nature and conditions of imprisonment, the punishment *par excellence* of civilized nations, and the most important of any in respect of the numbers to whom it is applied.

There are three other descriptions of confinement, which Bentham also discusses. *Quasi-imprisonment*, when the individual is confined within the district of his ordinary residence. *Relegation*, when he is sent away from his ordinary residence, and confined within a certain district in the state. *Banishment*, when he is removed from and forbidden to return to the state. All these are preferable to imprisonment in point of economy; they are defective in equality of operation; and though divisible in time, are scarcely so otherwise. Banishment has too little of example in it, but, under some circumstances, may prove reformatory. *Quasi-imprisonment*, by continuing the offender in old habits, may be corrupting, but *relegation*, by removing him from bad associations into a new sphere, holds out, in general, favourable prospects of his amendment.

The punishment of transportation, as enforced for many years past in the Australian colonies by the British government, has scarcely one of the qualities above mentioned as desirable. It fails especially in the great object of *example*; it neither deters others, nor corrects the offender himself. Instead of suppressing the power of commission, it is the fertile source of crimes. It does not supply the means of compensation to the party injured; it is not economical, but very costly to the state. Experience has fully confirmed the sagacity of Bentham's objections to this mode of punishment, and of Archbishop Whately's subsequent denunciation of it, both as a penal measure and as a branch of colonial policy. A valuable Report from the late Select Committee on Transportation,[1] has furnished unquestionable proofs "that the two main characteristics of transportation as a punishment are, inefficiency in deterring from crime, and remarkable efficiency, not in reforming, but in still further corrupting those who undergo the punishment; and that these qualities of inefficiency for good and efficiency for evil, are inherent in the system, which is not, therefore, susceptible of any satisfactory improvement." The committee have, therefore, recommended its abolition as soon as practicable. (See article Transportation.)

The rules of Bentham serve as well for the examination of capital, as of secondary punishments. Death has the advantageous qualities of completely annihilating the power of injury; of being analogous, as well as popular, in the case of murder; and of being always exemplary. On the other hand, it is not profitable, but costly, in depriving the community of one of its members; it is extremely unequal, according to the sentiments and condition of the offender; it is irrevocable, and, except in the case of murder, unpopular. Balancing all these considerations, the conclusion is arrived at, that the prodigality of capital punishment has been an error of legislators, and that there has been a want of reflection in applying it to a class of unhappy and degraded men, who attach but little value to life. If, for the purpose of deterring, it should be preserved at all, it should be for crimes which excite the public horror to the highest degree, such as atrocious murders, and those by which several lives are destroyed; in which cases the execution should be accompanied by every means of tragic effect. The non-execution of the law is mentioned as a collateral effect of the abuse of capital punishment; and this has indeed been the main argument of those, who, from Sir Samuel Romilly, down to the present day, have laboured for the mitigation of the criminal law of England. It is certain that excessive severity defeats its own object, in so far as it induces the persons entrusted with the administration of the laws, to substitute their own notions of right, from time to time, for the will of the legislature.

Bentham's nomenclature and classifications have been objected to as too arbitrary for the state of the science; but taking his theory of punishment as a part of his general system of legislation, it cannot but be regarded as a masterpiece of jurisprudence. It is only time to dismiss such a

[1] See Report of the Select Committee of the House of Commons on Transportation, ordered to be printed 3d August 1838.

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guide, when the inquirer shall have formed for himself a better abstract idea of punishment than Bentham's suggestions have furnished.

Theories of other jurists

The writers on different branches of penal law, since the commencement of the present century, have been so numerous, particularly on the Continent, that it would be vain to attempt to recapitulate here the various theories of punishment which have been offered. The names of Feuerbach, Mittermaier,[1] and of a host of other learned men in Germany, are an honour to jurisprudence, however little practical result may have arisen from their labours. Several recent French writers are worthy of reference; especially M. Charles Lucas, and the Duc de Broglie, on the punishment of death. Mr. E. G. Wakefield's essay on the same subject, and Mr. Montagu's collection of opinions on capital punishment, may be consulted with advantage. Archbishop Whately, in his well known Letters to Earl Grey on Secondary Punishments, has laid down very clearly and forcibly the principles by which the infliction of punishment ought to be regulated. "There are," says the Archbishop, "three and only three objects with a view to which punishments can be inflicted or threatened; 1st, *retribution*, or *vengeance*, or a desire to allot a proportionate suffering to each degree of moral guilt, independent of any ulterior consideration, and solely with a view to the past ill-desert of the offender. 2dly, What may be called *correction*, or the prevention of a *repetition* of offence by the same individual, whether by his reformation or removal. 3dly, The *prevention* of the offence generally by the terror of a punishment denounced, whether that object be attained by the example of a culprit suffering the penalty, or simply by the mere threat and apprehension of it. To these appropriate objects may be added another incidental advantage, not belonging to *punishment as such*, but common to them with other legislative enactments; the public benefit in an economical point of view which may be conceivably derived directly from a punishment, as when criminals are usefully employed on any public work, so as to make, in that way, some compensation to society for the injury done to it. Such a compensation, however, we should remember, must necessarily be so very inadequate, that this object should always be made completely subordinate to the main end, or ends, proposed in the denunciation of punishment." The archbishop then proceeds to shew that, regarding the prevention of crime as the great object, the infliction of just vengeance on the guilty is clearly out of man's province, inasmuch as the degree of moral turpitude can never be perfectly known but to the searcher of all hearts, and that no man, nor number of men, can be authorised thus to render evil for evil for its own sake, but on the contrary such a procedure is expressly forbidden, both by morality and the Christian religion. Of the other two objects of punishment, the archbishop explains that the prevention of a repetition of the offence by the same individual, is of less importance than the prevention of crime generally by the terror of example or threat, and after shewing that every man punished is an instance, *pro tanto*, of the inefficacy of the law, remarks, "this absolute perfection, indeed, the entire prevention of crime, is a point unattainable; but it is a point to which we may approach indefinitely; it is the point towards which our measures must be always tending, and we must estimate their wisdom by the degrees of their approach to it." Passing over thus briefly Archbishop Whately's exposition of penal principles, we proceed to notice a recent masterly work by a distinguished foreign jurist on this subject.

Theory of Rossi.

The work in question contains a complete theory of penal law, founded upon ethical principles different from those of Beccaria and Bentham. We refer to Rossi's valuable treatise. (*Traité de Droit Pénal*, par M. P. Rossi, Professeur du Droit Romain à l'Académie de Genève.) M. Rossi examines at large the foundation of the right to punish; whether it depends on a moral principle, or a material interest; whether it is to be traced to justice, or merely to utility? He rejects the notion of either individual, or general interest, conferring any such right; not admitting the ground of necessity, direct or indirect, or the existence of the social contract, upon which Beccaria relies. He holds that there exists a moral order in the world, binding upon all free and intelligent beings who are cognizant of it; that absolute justice is in perfect harmony with this moral order; and that all human justice, though not able to attain such perfection, ought to strive to approach it. Upon this justice, then, the right of punishment is founded; and punishment is defined as "the retribution made, by a legitimate judge, with ponderation and measure, of evil for evil." Thus, penal justice only acts when some duty is violated; for law and right are, under this theory, the same; and the natural effects of justice are instruction, intimidation, and amendment. A crime is defined as the violation of a duty towards society or individuals, requirable *(exigible)* in itself, and useful to the maintenance of public order; of a duty whose accomplishment can only be assured by the penal sanction, and whose infraction can be appreciated by human justice: and an enumeration of crimes and offences follows. In his third book, M. Rossi treats of the nature and end, the measure and effects of punishments, and then proceeds to give directions for the choice of them, pointing out the characteristics which should mark them, in order that the ends of human justice may be attained. Social justice, to be legitimate, must respect the conditions of moral justice; must take into account the imperfection of our means of knowledge and action; and must satisfy the exigencies of the material order in civil society. These rules will direct the choice of punishments, which in their application must be proportionate to the crime, and sufficient for the protection of the right. In order, then, to conform to the principle of justice, the legislator should choose such punishments as are,

(1st class) Personal,
Moral,
Divisible.

To be in relation with our imperfect means of knowledge and action, he should choose such as are,

(2d class) Appreciable,
Reparable, or remissable.

To satisfy the exigencies of the material order, punishments should be adapted to produce the effects which the legislator has in view, and should therefore be,

(3d class) Instructive and satisfying,
Exemplary,
Reformatory,
Fortifying (rassurante.)

Trying different kinds of punishments by these conditions, it will appear that the punishment of death is of the first class, except that it is not divisible; that it is appreciable, because applicable to every one, but not remissible; that it is instructive, because when applied to a small number of crimes, it is a moral lesson to society; that it is only under particular circumstances that it is exemplary, or calculated to intimidate those disposed to commit crimes; that of course the dead cannot be reformed; and that it so far fortifies or assures society, that it suppresses the individual's power of injury. In the result, M. Rossi declares capi-

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[1] Feuerbach's *Manual of Penal Law* has run through twelve editions, and the last edition, enriched with the notes of Mittermaier, is especially recommended. (*Lehrbuch des gemeinen in Deutschland gültigen peinlichen Rechts* von Dr. Anselm Ritter von Feuerbach, herausgegeben von Dr. C. J. A. Mittermaier. Giessen, 1836.)

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tal punishment admissible in itself, but in extreme cases only, and that its abolition is desirable when the advance of civilization shall have prepared men for so important a change.

M. Rossi regards all corporal punishment as of an immoral tendency, and considers imprisonment as the punishment best fitted to civilized society. He states the most essential object to be, such a separation of the convicted, as completely corresponds with the ends of penality, and moral amendment. But he seems to intend rather a kind of classification, than the entire separation of the prisoners from each other. He is opposed to transportation, and in a less degree to relegation and banishment, as being defective in the exemplary and reformatory qualities. Local interdiction, restraining the offender from frequenting particular districts, may, he thinks, be used with more advantage. He shows the immorality of infamous punishments, such as the pillory, and the impolicy and injustice of those which deprive offenders of civil rights, or of the whole, or the greater portion of their property. Lastly, he cautions the reader not to expect to find a punishment combining *all* desirable qualities, much less one that unites them all in the same degree.

In his fourth book, M. Rossi offers instructions as to the formation of a penal code; for the details of which the enquirer is referred to this very systematic and philosophical work. M. Rossi concurs with Beccaria and Bentham in many important particulars; and although the principle upon which the right to punish rests may not have been satisfactorily determined by any of these authorities, still the short notice we have given of them will shew how far they have advanced the science of penal jurisprudence.

Progress of penal legislation on the Continent.

The efforts made in penal legislation have, from a variety of causes, been bolder on the Continent than in Britain. The result has assuredly not been always successful; but it is by such beginnings that the true course is pursued for the formation of a good penal code; and no doubt can be entertained, that imperfect as these efforts have been, the condition of the people for whose use they were made, has been greatly benefited by them. Of all of them it may be said that they are deficient in respect of humanity, and the establishing a just proportion between crimes and punishments; and moreover erroneous in the including cases unfit, and excluding others fit for punishment, still leaving a vast discretion to the judges; but they have however, to the extent of the surface which they have covered, rendered a knowledge of the penal law practicable, and given great facility to its improvement by the recordation of its provisions. We shall give from one or two of the codes of criminal law now before us, an outline of their most prominent features.

The "Carolina."

The famous code collected under the auspices of the Emperor Charles V., and known under the name of the "Carolina," and which, we are told in the preface, "is properly the collection and confirmation of the laws which have been, from time immemorial, in use in the tribunals in Germany," is an elaborate work on penal jurisprudence; and in particular, is extremely copious and minute on the subject of torture, which was at that time deemed a highly efficient and indispensable instrument of criminal procedure.

The code commences, very properly, in respect of arrangement, with the judicial establishment; but after all, leaves it indeterminate with respect to the manner in which it is to be composed, and omits to give any exact and precise definition of the relative power of each of the several classes of individuals that enter into its formation. It appears clearly that there were to be certain established judges, and that to them were to be added all the nobles, *in the quality of judges and assessors*, not precisely fixing in what quality they are to act, or whether the decision was ultimately to rest with the judges, under the advice simply, or under the control, of those other judges or assessors. Next follows, not as might have been expected, an enumeration and definition of offences, and of the punishments annexed to them, but a minute account of cases, consisting of forty-one articles, in which torture may be employed to extract a confession of guilt. Afterwards come several articles respecting proof by witnesses; and then the distribution of offences, not as such, but by the punishment annexed to them.

In this code, the torture, as has been already mentioned, is most extensively applied. By article XLI. it is provided, that it shall be a sufficient ground for applying torture, in order to produce confession, in the instance of a man accused of incendiarism, whenever, in other respects, his conduct shall be suspicious. It is upon similar slight grounds throughout the code, that this most dreadful instrument is brought into action. The code, although defective in the arrangement of offences, contains some observations with regard to the indications of guilt from accompanying circumstances, that might not be found altogether useless at the present day.

The *Code Carolina* appears in the nineteenth century a barbarous piece of legislation, but was unquestionably a progress in its time. It had for its object the introduction of more regularity and measure in criminal proceedings and sentences. Its establishment was not effected without modification in some places, and even resistance in others. The following is a curious instance of an attempt to pervert its meaning. Article XI. declares, "it is never to be lost sight of, that prisons ought to be made and established for the safe custody of those detained, and not to be used as a dangerous punishment." A French translation of the *Carolina*, for the use of the councils of war of the Swiss troops, printed at Bienne in 1767, contains this commentary: "Although the law recommends humanity with respect to the nature of the prison in general, we may say that in cases of atrocious crimes, and where the vengeance of the public is absolutely interested, *the hardest and darkest dungeons ought to be used* for the confinement of criminals, provided only that their lives are not risked."[1] This code is still the foundation of criminal law throughout the greater part of Germany and Switzerland, subject to many modifications which it has undergone in the course of modern legislation.

Code of Corsica.

A criminal code was prepared for Corsica, under the direction of Louis XV. (*Code Corse, ou Recueil des Edits, &c., publiés dans l'Isle de Corse depuis sa soumission à l'obéissance du Roi*, Paris, 1778.) After enumerating the most prominent species of offences, such as treason, murder, theft, and homicide, and giving a view very far short of a complete one, of the field of criminal law, the framer of this code, (title IX.) has this article: "In respect of all other crimes and offences which are not mentioned above, we leave it to the prudence of the judges to condemn those who shall be guilty of them, to the punishment fitting for them, according to the exigence and circumstances of the case; not however allowing them the power of punishing with death, either natural or civil, except in the cases above enumerated;" leaving them, however, a considerable latitude of power in the cases so unprovided for; that is, in the cases in which they were thus invested with despotic authority; namely, that of punishing by hard labour in the galleys, either for a limited period, or for life.

Bavarian code.

In the above two instances, we have specimens of two penal codes, formed at comparatively early periods. Next follow examples of others of a more modern date. A code for Bavaria was drawn up, by direction of the king, by M.

[1] Rossi, Introduction, chap. ii.

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Bexon, and published by him in a folio volume at Paris in 1807. It professes to contain a complete system of criminal jurisprudence, including punishments and police. M. Bexon, however, has by no means pursued the clear and natural course, of first enumerating what are to be deemed offences, and then declaring the penal consequences of committing such offences. He begins with a system of police, under the title of *Legislation de la Sureté*, and then proceeds to state the several purposes to which this branch of administration is applicable. Now the characteristic feature of a system of police, is, that it is to serve for the prevention of offences; so that we have, at the outset, the rules of a system of administration employed for the prevention of certain acts which remain to be stated. In the subdivisions of the work, the dispositions are neither clear nor convenient. Crimes, punishments, tribunals, and procedure, are mixed together, instead of being kept separate and distinct, as they ought to be. The penal code itself adopts the old principle of division, and classes offences under the several heads of crimes against the public; crimes against persons; and crimes against things. But what is new in this work, is the distribution of these several species of offences into three distinct classes, according to their supposed delinquency, and which are denominated, 1. *Contraventions et Fautes.* 2. *Delits.* 3. *Crimes.* This is obviously an unnatural and inapposite system of division, as it supposes that each class of offences is susceptible of only three stages of extenuation or aggravation, while, in fact, the same act is capable of varying, and continually does vary, and that by extremely minute steps, throughout all the gradations of guilt.

Code Napoleon.

The present penal legislation of France is, without doubt, far more rational and humane than that which existed before the Revolution. Still the Code Napoleon, the offspring of that imperial power which re-established confiscation, and re-opened Bastilles, is, in many respects, unworthy of the present state of French civilization. The penal branch of the Code Napoleon was decreed the 12th of February 1810, and promulgated the 22d of the same month. It is comprised within 114 moderately-sized octavo pages. It begins by declaring that a violation of the law, cognizable by the police, is a *contravention;* that a violation of the law, which is visited by a correctional punishment, is an *offence;* and that a violation of the law, which is visited by an afflictive and infamous punishment, is a *crime.* This division is quite arbitrary, and displays too much disregard of the intrinsic nature of human actions. Certainly it does not coincide with M. Rossi's theory of the concordance of penal law with the moral order of things; for actions are in many instances placed in the catalogue of crimes and offences (such as the assembling together of twenty-one persons in one place, art. 291,) which have nothing like immorality about them. The several species of punishments employed are then enumerated, and are, 1. Death. 2. Hard labour for life. 3. Transportation. 4. Hard labour for limited periods. 5. Seclusion. 6. The *carcan*, (analogous to the pillory). 7. Banishment. 8. Civil degradation. 9. Imprisonment during a limited period in a house of correction. 10. Suspension, temporary, of certain civil rights. 11. Making satisfaction to the party injured. To these are added, in the cases specified, the drawing a ball, to be attached to the feet; imprinting on the right shoulder, by means of a red-hot iron, certain letters; standing on the *carcan*, having above the head affixed a writing in large and legible characters, mentioning the name of the patient, his profession, residence, punishment, and the occasion of it. Some of the punishments are also attended with certain civil disabilities, of which some are temporary, others perpetual. With regard to forfeiture, which figures to so great an extent in the English penal code, it is here declared not to attach in any case as the necessary consequence of conviction, but to have place only when expressly pronounced to be a part of the punishment, and the instances in which it is used are comparatively few; and even then the forfeited property remains liable to all just encumbrances, and to the rightful portions of the children, or other descendants.

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Offences are divided into two classes, 1st, those affecting the public; and 2dly, those affecting individuals. Under the first class, the principal offences comprised are, offences against the exterior and interior of the state, levying war, counterfeiting the coin; and malversation on the part of public functionaries. Under the second head are included, offences affecting particular assignable persons, such as murder, and other personal injuries, perjury, and offences against property.

Under this code, the judges and officers of justice are placed in a somewhat undignified light, by various pecuniary fines of from 16 to 200 francs, for pronouncing judgment notwithstanding an appeal, or other acts of misconduct. The policy of thus setting a money price on infractions of judicial duty is very questionable, although the judges should clearly be amenable to punishment of some kind for the slightest malversation of their functions.

Capital punishment is authorized by the Code Napoleon in many cases where it is obviously not justifiable by necessity, such as, for counterfeiting the coin, for destroying the national fortifications, &c. And the application of such degrading punishments as branding and the *carcan*, to a pretty wide class of offences, savours little of refinement. The establishments for hard labour, called the *bagnes*, though lately improved, are carried on upon a brutal system of force, which is disgraceful, as the penal instrument of a highly civilized nation.

Prussian code.

The present criminal code of Prussia consists of 1577 articles. With much that is wise and humane, it mixes some enactments of quite revolting barbarity. It, in fact, confuses together a number of moral precepts, of administrative regulations, of legal dogmas, and penal enactments. More than twelve articles authorise the breaking the offender on the wheel, making nice distinctions where the punishment is to begin at the upper part of the body, and where at the legs. Hanging, decapitation by the axe, flogging with rods, and whips, are all specified as modes of punishment, and incendiaries are, in certain cases, to be burned alive. The definition of treason is fearfully vague. "The voluntary act of a subject, by which the state, or its chief, are attacked in an immediate manner," art. 91; and there is the most striking immorality in the manner in which the wives of deserting soldiers are punished, if they do not betray their husbands, even in certain cases in which they may be declared innocent by the law.

Austrian code.

The penal code of Austria is, upon the whole, of a milder character than that of Prussia, but its forms of procedure commit so much discretionary power to the administrators of the law, as to leave the people little real security against oppression. The 14th article authorizes solitary imprisonment of so severe a kind, as almost to amount to a lingering death. The punishment consists in "shutting up the convict in prison, without any communication, with as much light and space as is requisite to keep the prisoner in health, who is to have heavy irons constantly on his hands and feet, and round his body an iron ring fixed by a chain, except during labour; his diet shall be wholly bread and water, and every other day a warm mess, but never of meat; some bare boards are to form his bed, and all conversation is forbidden him." Men are to be flogged with a staff, and women and children with rods, for many offences. Forging paper-money is punished with death; blasphemy, or spreading false religious doctrines, with imprisonment from six months to ten years. We will only add one curious specimen of a *contravention*, "Whoever endeavours to persuade an Austrian subject to establish himself in a foreign country, shall be punishable with confinement from one month to six months."

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Penal laws in America.

The criminal law varies in every one of the States which form the United States of America, and consequently, taking the whole Union, there is a great inequality in the system of punishments, and more especially of capital punishments. The disproportionate penalties inflicted in different States for the same offence cannot but have an unfavourable tendency upon morals, in a country which, for all purposes of intercourse and traffic, is essentially *one*, although possessing various local legislatures. Many of these criminal laws will be found abstracted in Mr. Crawford's Report, and in the Second Report of the Criminal Law Commissioners. The criminal code of Louisiana, drawn up by Mr. Livingston, is deservedly celebrated, and is remarkable for not inflicting capital punishment upon any crime whatsoever.

Having thus adverted to some specimens of criminal legislation abroad, we shall conclude with a notice of the progress that has of late years been made in England in this respect.

State of the penal law of England.

Notwithstanding the examples that have been thus set us abroad, the British legislature has shewn little disposition to collect into one body of criminal jurisprudence the various decisions and enactments which now constitute the penal system of this country. Great authorities, both dead and living, may indeed be quoted in support of a revision of our whole penal system, among whom none are entitled to more weight than Mr. Justice Blackstone, who in his Commentaries expressed himself decidedly in favour of such a revision, (b. iv. ch. 1.) Little or nothing, however, was done towards the improvement of the criminal law, until the late Sir Samuel Romilly, when he obtained a seat in Parliament, brought in a series of bills, having for their object to mitigate, in certain cases, the severity of the penal law, by substituting for the punishment of death transportation for life, or for limited periods. He procured the repeal of so much of the statute of 8th Elizabeth, as took away the benefit of clergy from persons stealing privily from the person, and also the repeal of capital punishment in cases of stealing to the amount of 40s. on navigable rivers, and of stealing from bleaching-grounds. He failed in his attempts to repeal the punishment of death in cases of stealing to the amount of 5s. privately in a shop, and to the value of 40s. in a dwelling-house; but as we shall presently see, these objects have been subsequently effected. Sir Samuel Romilly, and after him Sir James Mackintosh, had the merit of contending against the erroneous principle of severe punishment rarely inflicted, and advocating that of the uniform infliction of milder punishments, duly proportioned to the magnitude of offences; and it is to their exertions that is attributable much of the attention which the legislature has since bestowed upon the subject. We proceed to enumerate some recent statutes which have gradually mitigated the severity of our penal law, and otherwise improved the administration of criminal justice.

Recent legislation.

The act 7th Geo. IV. cap. 64, (1826), "for improving the administration of criminal justice in England," among other provisions, enables bail to be taken in cases of felony, where there is not a strong presumption of guilt.

The act 7th and 8th Geo. IV. cap. 27, (1827), repeals upwards of 130 statutes, and parts of statutes, relative to the benefit of clergy, and to larceny and other offences connected therewith, and to malicious injuries to property, and to remedies against the hundred, thereby clearing the way for the four acts next mentioned, (commonly called Sir Robert Peel's), viz.:

The act 7th and 8th Geo. IV., cap. 28, (1827,) which, among other provisions, wholly abolishes the benefit of clergy, and declares that no person shall suffer death, unless for some felony previously excluded from benefit of clergy.

The act 7th and 8th Geo. IV., cap. 29, (1827,) for "consolidating and amending the laws relative to larceny, and other offences connected therewith," which abolishes the distinction between grand and petty larceny, and declares that larceny shall be punished with transportation, or imprisonment with whipping. It then proceeds to inflict punishment on various offences of this description, amongst which, for robbery from the person, death; for stealing from the person, transportation, or imprisonment with whipping; for burglary, housebreaking, stealing in a dwelling-house to the value of L.5, and cattle and sheep-stealing, death. It also gives summary jurisdiction to justices of the peace over a variety of petty depredations.

The act 7th and 8th Geo. IV., cap. 30, (1827,) "for consolidating and amending the laws relative to malicious injuries to property," inflicts the punishment of death for arson; for setting fire to coal mines, or to ships; and for riotously demolishing buildings, or machinery; also transportation, or imprisonment with whipping, for the destruction of manufactures, or machinery, or the destruction, or injury of sea-banks, turnpikes, dams, cattle, stacks of corn," &c. It also gives summary jurisdiction to justices, in cases of injuries to trees, or fruit, and of various other petty trespasses.

The act 7th and 8th Geo. IV., cap. 31, (1827,) which consolidates and amends the laws relative to remedies against the hundred, for riotous destruction of property.

The act 9th Geo. IV., cap. 31, (1828,) repeals upwards of fifty statutes relative to offences against the person; enacts the punishment of death for murder, malicious shooting, cutting and maiming, administering poison, attempting to drown, suffocate, &c. and for rape and sodomy; and transportation or imprisonment for various other offences of a personal nature. It also gives summary jurisdiction to justices of the peace over common assaults.

The act 11th Geo. IV., and 1st Will. IV., cap. 66, (1830,) abolishes capital punishment in all cases of forgery, except those particularly specified, viz., forgery of the royal seals, or sign manual, of Exchequer bills, bank notes, wills, bills of exchange, promissory notes, or money-orders, of transfers of stock, or powers of attorney, and other forgeries connected with the preceding. Forgeries of other descriptions are subjected to transportation or imprisonment.

The act 2d Will. IV., cap. 34, (1832,) abolishes capital punishment for all offences whatever relative to the coin, and subjects them to transportation, or imprisonment.

The act 2d and 3d Will. IV., cap. 62, (1832,) substitutes transportation for life for capital punishment, in cases of stealing in a dwelling-house to the value of L.5, and of cattle and sheep stealing; so far altering the provisions of the larceny act, 7th and 8th Geo. IV.

The act 2d and 3d Will. IV. cap. 123, substitutes transportation for life for capital punishment in all cases where the latter is inflicted by the 11th Geo. IV., and 1st Will. IV., except only the forgery of wills, and of powers of attorney for stock.

The act 3d and 4th Will. IV., cap. 44, (1833,) abolishes capital punishment for dwelling-house robbery as inflicted by the larceny act, and substitutes transportation or imprisonment.

The act 4th Will. IV., cap. 26, (1834,) abolishes the practice of dissecting, or hanging in chains, persons convicted of murder.

The act 4th and 5th Will. IV., cap. 67, (1834,) abolishes capital punishment in case of returning from transportation.

The act 5th and 6th Will. IV., cap. 33, (1835,) extends the powers of taking bail in cases of felony, notwithstanding confession, or presumption of guilt.

The act 5th and 6th Will. IV., cap. 81, (1835,) abolishes capital punishment for letter stealing and sacrilege, and substitutes transportation or imprisonment.

The act 1st Victoria, cap. 23, (1837,) abolishes the punishment of the pillory in all cases whatsoever.

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The act 1st Victoria, cap. 84, (1837,) abolishes entirely the punishment of death for forgery, as retained by the 2d and 3d Will. IV., or any other existing laws, and substitutes transportation or imprisonment.

The act 1st Victoria, cap. 85, (1837,) makes new provisions for the punishment of offences against the person. Capital punishment is inflicted for administering poison, or doing bodily injury with intent to murder. Other offences with intent to commit murder, or for acts with intent to maim or disfigure, or to procure abortion, are made punishable with different degrees of transportation or imprisonment.

The act 1st Victoria, cap. 86, (1837,) limits capital punishment for burglary, to cases where that offence is accompanied by violence. In other cases, transportation or imprisonment.

The act 1st Victoria, cap. 87, (1837,) alters the former laws relative to robbery, and some other offences. The punishment for robbery, attended with cutting or wounding, is declared to be death, but in other cases, transportation or imprisonment. Obtaining property, by accusation of unnatural crimes, stealing from the person, assaults with intent to rob, obtaining property by menace, and plundering wrecks, are subjected to transportation or imprisonment.

The act 1st Victoria, cap. 88, (1837,) amends the laws relating to piracy, and subjects that offence to death, where murder is attempted, or to transportation or imprisonment, at the discretion of the court.

The act 1st Victoria, cap. 89, (1837,) amends the laws relating to arson, punishing with death the offences of setting fire to a dwelling-house, any person being therein, of setting fire to ships with intent to murder, and of hanging out false lights to shipping. For other offences under this head, transportation or imprisonment.

The act 1st Victoria, cap. 90, (1837,) substitutes transportation, during specified terms of years, for transportation for life, in a variety of cases particularized in the act.

Lastly, the act of 1st Victoria, cap. 91, (1837,) mitigates the punishment of death still further, by substituting transportation or imprisonment for it, in the cases of riotous assemblies, of seducing from allegiance, of certain offences against the revenue laws, and others enumerated in the act.

A reference to the acts above cited, will shew the gradual mitigation which has, within the last few years, been taking place in the severity of the ancient criminal law of England. Much has thus been effected in the way of the consolidation and arrangement of different branches of law under their proper heads, in particular statutes. Still, since nothing like codification has yet been attempted, the definitions and classifications of both crimes and punishments continue very vague and uncertain. All that we can usefully record here on the subject, is to state what crimes and punishments are understood, in a general sense, to mean by English lawyers.

Definitions of crimes &c.

A crime, says Blackstone, is the commission, or omission, of an act, in violation of a public law, either forbidding or commanding it. (Commentaries, vol. iv. ch. 5.)

A misdemeanour imports a crime which does not amount to felony, but is the subject of indictment. (Commentaries, vol. iv. ch. 5.) It is generally punishable with fine and imprisonment.

A felony is such a crime as, independently of other punishments, occasioned at common law a total forfeiture of lands, or goods, or both. (Commentaries, vol. iv. ch. 55.)

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A felony generally carries with it the idea of a capital crime. But felonies are either punishable with death, or not. Felonies are punishable with death, where the offence was excluded from benefit of clergy by the common law, or by any statute, before the 7th and 8th Geo. IV., cap. 28, or where, since that statute, they have been made capital; provided that in neither case the capital punishment has been taken away by any subsequent statute. In other cases, felonies are punishable either in the particular manner described by the statute relating thereto, or otherwise by transportation, or imprisonment, with whipping, if a male, at the discretion of the court.

Misprisions, and contempts, are a species of misdemeanour, affecting the king, or his government, or courts of justice.

Misprision of felony, however, in its ordinary sense, is a misdemeanour consisting in the knowledge or concealment of a felony committed by another, and is punishable by fine and imprisonment. (Burn's Justice, title *Felony*.)

Commission of inquiry into criminal law.

We should add, that on the 23d July, 1833, a Royal Commission was issued for the purpose of digesting into one statute all the statutes and enactments touching crimes, and the trial and punishment thereof, and also of digesting into another statute all the provisions of the common or unwritten law touching the same, and for inquiring and reporting how far it might be expedient to combine both those statutes into one body of the criminal law, repealing all other statutory provisions, or how far it might be expedient to pass into a law the first mentioned statute only, and generally for inquiring and reporting as to the consolidation of the other branches of the existing statute law. The question of codification is discussed in the first report of the commissioners dated 24th June, 1834, which, after a very elaborate statement of the difficulties which the present uncertain state of the law presents to such an undertaking, expresses a confident opinion that a digest of the statute with the common law, into one criminal code, would tend greatly to the improvement of the jurisprudence of the country. The second report, dated 9th June, 1836, is devoted partly to the question of the defence of prisoners by counsel, (since authorized by the act 6th and 7th Will. IV., cap. 114,) and to that of the infliction of capital punishment. The commissioners think that the punishment of death ought to be confined to the crime of high treason, and to offences which consist in, or are aggravated by such acts of violence to the person as directly endanger human life, a list of which acts they subjoin. The third report, dated 10th March 1837, is specially devoted to the subject of juvenile offenders, and expresses the opinion of the commissioners, that it would not be advisable to make any distinction in the mode of trial between adult and juvenile offenders, except by increasing the summary jurisdiction of magistrates in the manner therein mentioned; and that the extension of such summary jurisdiction within certain limits, would be a safe and beneficial alteration of the law, and would tend to diminish juvenile crime.

The reader is referred to these reports for very valuable information and suggestions, in regard to the amendment and consolidation of the penal law of England, and in particular for a full explanation of the difficulties with which those important objects have been, and continue to be, surrounded, and which, without some technical knowledge, it is by no means easy to appreciate.

Punjab || Puno.

PUNJAB, or FIVE WATERS, an extensive region of Hindustan, principally situated in the province of Lahore, but including Moultan. The province of Lahore is also frequently named the Punjab. This tract has no very definite boundary. On the east the boundary is properly the ridge of the Snowy Mountains, from which spring the five rivers by which it is watered; but, in its more restricted sense, it means the country situated to the west of this hilly tract. This territory is watered by five celebrated streams, that fall into the Indus, namely, the Sutleje, the Beyah, the Ravey, the Chinaub, the Jhylum or Belut. It is very extensive, and remarkably fertile, abounding in all the necessaries of life, besides wine, sugar, indigo, cotton, and many luxuries. The tract between the Jhylum and the Indus contains salt-mines, that furnish inexhaustible stores of this article, which is largely exported. The lower part of the country is inundated, like Bengal, by the overflowing of the rivers during the periodical rains.

PUNO, a department and city of the republic of Southern Peru, in South America, lying to the eastward of Arequipa and to the south of Cuzco. The surface of the country is nearly all high table-land, being in few places less than 10,000 feet above the level of the sea. The climate is cold compared with that of the coast, but on that account it is very healthy. The hordes of domestic animals are numerous, consisting of llamas, sheep, horses, mules, asses, pigs, guanacas, alpacas, and cattle in great abundance. The llama is peculiar to the Peruvian Andes, and of great use, particularly upon roads impassable for mules, or in places where forage is scarce. It is employed in carrying ores from the mines, charcoal, corn, and other burdens. From the great height of this district, agriculture is limited to a few objects. The principal are, potatoes, quinoa, rye, barley, and oats; but the three latter do not ripen to seed, and are cut green for horses. Puno contains a number of silver mines, which in productiveness were at one time only second to those of Potosi. The most noted is that of Laycacota, or Salcedo, as it is now called, after its first proprietor. The mines are situated in a high range of hills forming the western boundary of the great lake of Titicaca. These mountain ridges are chiefly composed of a porphyritic rock, which reposes on a sandstone formation, similar to that of the red marl and sandstone of the British islands, and to the great red sandstone formation of the continent of Europe. In its general disposition, as well as in its mineralogical characteristics, the porphyry of Puno corresponds exactly with those metalliferous porphyries which have produced the immense riches of the Real del Monte, of the Bolanos, and partly of the Guanaxuato mines in Mexico, and with those of Hungary and Transylvania; and, like them, it abounds in veins containing the precious metals. The hills of Laycacota, Cancharani, and San José, are one continuous range formed of this porphyry nearly to their bases, and in it are situated the rich veins of silver ore which have rendered the place so celebrated. The produce of these mines, particularly that of Laycacota, during the seventeenth century, was enormous. It appears from documents of indisputable authenticity, that the ore extracted in the year 1668 from the mines of Salcedo produced upwards of a million and a half of dollars. They were afterwards neglected, and only towards the end of the last century they again began to be worked with activity. In the year 1805, they yielded 96,528 marcs of silver. The annual average produce between 1796 and 1820 amounted to nearly 30,000 marcs. Since that time they have been again neglected; and in the month of April 1831 only one mine was worked, which belonged to an Englishman. The mining district of Puno being surrounded on all sides by arid mountains, is almost destitute of wood, so that fuel is scarce. This is one of the reasons why the ores are treated by amalgamation, and not by smelting in furnaces, to which they are peculiarly well adapted, from their being very frequently associated with the ores of lead and copper.

Puno.

The grandest natural feature of South America, next to the cordilleras of the Andes, is the Laguna de Puno, commonly called Titicaca or Chucuito. It is situated between the two cordilleras, and is enclosed by the surrounding mountains. According to Mr Pentland, it is placed 12,795 feet above the level of the sea, and is consequently the largest lake in the world found at such an elevation. The same traveller informs us that it occupies an area of almost 4000 geographical square miles. With regard to its depth, he states that from accidental circumstances he was not able to obtain deeper soundings than a hundred and twenty fathoms (which, however, is a much greater depth than any hitherto assigned to the lake); "but," he observes, "from the precipitous cliffs which in many parts of it form the shores, and its islands, I am persuaded that its depth in the central portion is much greater. The lake of Titicaca receives numerous streams at its northern extremity, but by no means so great a mass of water as might be expected from the height of the Andes that surround it." The principal streams which supply the lake are those which on its northern side form the rivers of Asangaro, descending from the cordillera of Crucero and San Juan del Oro, and that of Lagunillas, which rises in a chain of small lakes in the western cordillera. The latter is probably the stream which Dr Meyen calls the Rio Jussecano, which, he says, is one of the largest rivers falling into the lake of Titicaca. One of its sources is in an alpine sheet of water called Laguna Compuerta; and not far from it is another lake called Lagunilla, to which Rivero assigns an elevation of more than 15,000 feet above the level of the Pacific. The only outlet of the lake of Titicaca is the river Desaguadero, which issues from its south-western extremity in lat. 16. 38. 10. and is an inconsiderable stream when compared to the immense extent of the lake from which it proceeds. This anomaly, however, may easily be explained by the great amount of spontaneous evaporation to which its surface is exposed, in an extremely dry and rarefied atmosphere, owing to its excessive elevation. Mr Pentland found the width of the river Desaguadero, in the beginning of the rainy season, and close to its origin in the lake, to be forty-six yards; its course was scarcely two miles an hour, but its depth was considerable. The lake of Titicaca is studded with small steep islands. It derived its name of Titicaca from one of the largest of these, which is situated at the south-eastern extremity. It was held in great veneration by the natives, as they believed it to be the spot where Manco Capac received his divine commission to civilize the inhabitants of the country. Numerous Peruvian ruins are still to be seen upon it. "The low banks of the lake," says Dr Meyen, "are lined with rushes; and farther inwards its waters are covered with *Myriophyllum chuquitense*, a new species. Rushes are here a plant of great utility, being employed by the natives for almost as many uses as the bamboo in the East Indies. They supply the place of wood, which is wanting throughout the whole valley of the Desaguadero. The huts of the poor are made of rushes, as also mats for the floor, and bed-covers. The boats with which the rivers and the lakes are navigated are also made of rushes twisted together; the rudder and the mast alone are of wood, and form one of the most valuable possessions of the poor natives. These boats are frequently made with great taste and ingenuity. The smaller ones carry only three or four persons. The larger venture to some distance from the banks of the lake, which, even in calm weather, is subject to a heavy swell. The lake abounds in fish and waterfowl." Its waters are said to be "bitter" and impure, yet they are drunk by the cattle, and even by the Indians. It appears that the extent of the lake has diminished even within the historical period of this continent; for a Spanish

Punugga || Purchas.

writer, soon after the conquest of Peru by the Spaniards, in describing the gigantic Peruvian monuments of Tiaguanaco, says that the waters of the lake washed their walls. These ruins are now elevated many feet above the level of the lake, and stand at a considerable distance from it. The valley of the Desaguadero and the lake form together one continuous and immense basin, which, by a calculation of Mr Pentland, occupies an area of above 16,000 geographical square miles. The valley of the Desaguadero is necessarily in the direction of the two chains which enclose both it and the lake. In its southern portion it runs nearly parallel with the meridian; but north of latitude 17° it forms an angle of almost 45° with that line, running very nearly north-west by north, and south-east by south. It is entirely bounded by mountains, having no outlet towards the sea; and the rivers which descend into it are either lost in the sandy soil, or empty themselves into the lake of Titicaca at its northern extremity.

The city of Puno is situated upon the western shores of the lake of Titicaca, in lat. 15. 50. S. and long. 70. 22. W. from Greenwich, at an elevation of 12,832 feet above the level of the sea. It was formerly a rich and beautiful place, but has now very much declined in all respects. It possesses some woollen manufactures, with which it supplies Lima and Arequipa; and it contains a population of about 9000. The number of inhabitants in the department has been estimated at 30,917.

PUNUGGA, a village of Northern Hindustan, in the province of Bootan. The mountains in the vicinity are the highest in Bootan. Long. 89. 23. E. Lat. 27. 23. N.

PURCELL, Henry, the most distinguished musical composer that England has produced. He was born in 1658, and died in 1695. At the early age of eighteen his genius and attainments procured him the appointment of organist of Westminster Abbey. His genius for composition was original and vigorous, as is evinced by his various works for the church, the chamber, and the theatre. A detailed analysis of some of these productions is given by Dr Burney in the third volume of his History of Music. Purcell entertained the highest respect for the great Italian composers of his period. Burney (vol. iii. page 508) says, in a proper spirit of liberality, "Let those who shall think Purcell has sacrificed the national honour by confessing his reverence for the productions of Italy, compare the secular productions of English musicians, from the death of Queen Elizabeth to the year 1683, with those of Carissimi, Cesti, Stradella, and innumerable others of great abilities, and, if they do not equally hate music and truth, they will admire Purcell's probity as well as his genius." Burney remarks afterwards (page 510), with a just feeling towards Purcell's great abilities, "If a parallel were to be drawn between Purcell and any popular composer of a different country, reasons might be assigned for supposing him superior to every other great and favourite contemporary musician in Europe." Purcell was interred in Westminster Abbey, and a monument erected there to his memory.

PURCHAS, Samuel, an English divine, famous for compiling a valuable collection of voyages, was born in 1577, at Thacksted, in Essex. After studying at Cambridge, he obtained the vicarage of Eastwood, in his native county; but leaving that cure to his brother, he settled in London, in order to carry on the great work in which he was engaged. He published the first volume in folio in 1613, and the last four twelve years afterwards, under the title of Purchas his Pilgrimage, or Relations of the World, and the Religions observed in all Ages and Places. Meanwhile he was collated to the rectory of St Martin's, Ludgate, in London, and made chaplain to Dr Abbot, archbishop of Canterbury. His Pilgrimage, and the learned Hackluyt's Voyages, led the way to all the other collections of the same kind, and have been justly valued and esteemed. But unhappily, by his publishing, he involved himself in debt, and died in embarrassed circumstances, about the year 1628. The works of Purchas and Hackluyt form the most valuable collections of the kind in existence; and, were such things ever done in this country, we should strongly recommend the republication of *annotated* editions of both at the public expense; for such an undertaking, though of the highest utility, would far transcend the means of any individual publisher.

Purdhaungur || Purgatory.

PURDHAUNGUR, a hill-fortress of Hindustan, in the province of Bejapore, taken by the Mahratta chief Savajee in 1668. Latitude not ascertained.

PURDIE'S Isles, a ledge of rocks and small islets, situated on the southern coast of New Holland, opposite Point Bell, in long. 133. 5. E. lat. 32. 16. S. They form part of Nuyt's Archipelago.

PUREG, a village of Mekran, in Persia, on the site of Para, the ancient capital of Gedrosia, where Alexander terminated his march on his return from India.

PURFLEW, a term in heraldry, expressing ermines, peans, or any of the furs, when they compose a bordure round a coat of arms. Thus it is said, he beareth gules, a bordure, purflew, vairy; meaning that the bordure is vairy.

PURGATION, the art of purging, scouring, or purifying a thing, by separating or carrying off any impurities that may be found therein. Thus, in pharmacy, purgation is the cleansing of a medicine by retrenching its superfluities; in chemistry, it is used for the several preparations of metals and minerals intended to clear them of their impurities; and in medicine, purgation is an excretory motion arising from a quick and orderly contraction of the fleshy fibres of the stomach and intestines, whereby the chyle, corrupted humours, and excrements, lodged therein, are protruded further and further, and at length quite excluded by stool.

Purgation, in *Law*, signifies the clearing a person's self of a crime of which he is suspected and accused before a judge. This purgation is either canonical or vulgar. Canonical purgation is prescribed by the canon law, and the form of it in the spiritual court is usually thus: The person suspected takes his oath that he is innocent of the crime charged against him, and at the same time brings some of his neighbours to make oath that they believe he swears truly. Vulgar purgation was anciently by fire or water, or else by combat; and was practised here till abolished by the canons.

PURGATORY, a place in which the just, who depart out of this life, are supposed to expiate certain offences which do not merit eternal condemnation. Broughton has endeavoured to prove that this notion was held by Pagans, Jews, and Mahommedans, as well as by Christians; and it cannot be questioned that, in the days of the Maccabees, the Jews believed that sin might be expiated by sacrifice after the death of the sinner.

Much abuse has been poured upon the Church of Rome for her doctrine of purgatory, and many false representations have been made of the doctrine itself. The following view of it is taken from a work which is considered as a standard by the British Catholics. First, every sin, how slight soever, though no more than an idle word, as it is an offence to God, deserves punishment from him, and will be punished by him hereafter, if not cancelled by repentance here. Secondly, such small sins do not deserve eternal punishment. Thirdly, few depart this life so pure as to be totally exempt from spots of this nature, and from every kind of debt due to God's justice. Fourthly, few will therefore escape without suffering something from his justice for such debts as they have carried with them out of this world, according to that rule of divine justice, by which he treats every soul hereafter according to its works, and according to the state in which he finds it in death. From these propositions,

Purification. which the Catholic considers as so many self-evident truths, he infers that there must be some third place of punishment; for since the infinite goodness of God can admit nothing into heaven which is not clean and pure from all sins, both great and small, and as his infinite justice can permit none to receive the reward of bliss who as yet are not out of debt, but have something in justice to suffer, so there must of necessity be some place or state where souls, departing this life, pardoned as to the eternal guilt or pain, yet obnoxious to some temporal penalty, or with the guilt of some venial faults, are purged and purified before their admission into heaven. This is what the Catholic is taught concerning purgatory; and though he knows not where it is, of what nature the pains are, or how long each soul is detained there, yet he believes that those who are in this place, being the living members of Jesus Christ, are relieved by the prayers of their fellow members here on earth, as also by alms and masses offered up to God for their souls. And as for such as have no relations or friends to pray for them or give alms, or procure masses for their relief, they are not neglected by the church, which makes a general commemoration of all the faithful departed in every mass, and in every one of the canonical hours of the divine office.

Such is the doctrine of purgatory as taught by the Church of Rome. (See 2 Macc. xii. 43, 44, 45; St Math. xii. 31, 32; and 1 Cor. iii. 15.) By Protestants the books of Maccabees are not acknowledged as inspired Scripture; but if they were, the texts referred to would rather prove that there is no such place as purgatory, since Judas did not expect the souls departed to reap any benefit from his sin-offering till the resurrection. Our Saviour in St Luke speaks of remission in this world, and in the world to come, but surely neither of these is purgatory. The world to come is the state after the resurrection, and the remission spoken of is the sentence of absolution to be pronounced upon the penitent from the seat of general judgment. In the obscure verse referred to in the epistle to the Corinthians, the apostle is, by the best interpreters, thought to speak of the difficulty with which Christians should be saved from the destruction of Jerusalem. Of the state of souls departed he cannot well be supposed to speak, as upon disembodied spirits fire could not make any impression. We cannot help, therefore, thinking, with the Church of England, that "the Romish doctrine of purgatory is a fond thing, vainly invented, and grounded on no warranty of Scripture."

PURIFICATION, in matters of religion, a ceremony which consists in cleansing any thing from a supposed pollution or defilement.

The Pagans, before they sacrificed, usually bathed or washed themselves in water; and they were particularly careful to wash their hands, because with these they were to touch the victims consecrated to the gods. It was also customary to wash the vessel with which they made their libations. Previously to the duty of prayer the Mahommedans also use purifications, which are of two kinds; namely, either bathing, or only washing the face, hands, and feet. The first is required only in extraordinary cases, as after having lain with a woman, touched a dead body, or the like. But lest so necessary a preparation for their devotions should be omitted, either where water cannot be had, or when it may be of prejudice to a person's health, they are allowed in such cases to make use of fine sand or dust instead of it; and then they perform this duty by clapping their open hands on the sand, and passing them over the parts, in the same manner as if they were dipped in water.

There were also many legal purifications amongst the Hebrews. When a woman was delivered of a male child, she was esteemed impure for forty days, and when of a female, for sixty; at the end of which time she usually carried a lamb to the door of the temple to be offered for a burnt-offering, and a young pigeon or turtle for a sin-offering, and by this ceremony she was cleansed or purified. Purim ‖ Purpure.

PURIM, or *the* FEAST *of* LOTS, a solemn festival of the Jews, instituted in memory of the deliverance they received, by means of Mordecai and Esther, from Haman's wicked attempt to destroy them.

PURITAN, a name formerly given in derision to the dissenters from the Church of England, on account of their profession to follow the pure word of God, in opposition to all traditions and human constitutions. It was likewise given in the primitive church to the Novatian schismatics, because they would never admit to communion any one whom dread of death had led to apostatize from the faith.

PURLINS, in building, those pieces of timber which lie across the rafters on the inside, to keep them from sinking in the middle of their length.

PURNEAH, an extensive district of Bengal, forming the north-western division of that province, and situated about the twenty-sixth degree of north latitude. Its boundaries are, to the north the Morung Hills, in the Nepaul territories; on the south Monghir and Rajemahl; on the east Dinagepoor; and on the west Tirhoot and Baglipoor. It is a fertile, compact, and well-watered flat, comprehending 5119 square miles, intersected by various streams, is extremely fertile, and abounds in luxuriant pastures, on which are fed remarkably fine cattle, which are employed in the work done by horses in Europe. These bullocks are of fine proportions, and of a large size, and very superior to the draught cattle in Calcutta. It produces also rice, oil, pulse, wheat, besides other vegetables; opium and saltpetre for foreign commerce; and valuable timber from the Morung forests, which is cut in hot weather, and floated down the rivers in the rainy season. It is also celebrated for its sugar and indigo, the latter being one of its staple commodities; and it exports a considerable quantity of ghee, or butter of buffaloes, clarified. About 1796, from an official inquiry into the population of Purneah, it was found to contain 89,914 husbandmen holding leases, 22,324 artificers paying ground-rent, in 2784 villages, and on 2531 square miles. From official inquiries in 1801, it was found to contain 1,450,000 inhabitants, in the proportion of seven Mahommedans to ten Hindus. The chief rivers are the Cosah and Muhanada. In 1722 Sief Khan was appointed governor of Purneah, with absolute power over that district, and with permission to conquer from the independent rajahs near him all the territory that he could. He accordingly made considerable additions to the territory during the twenty-seven years which he ruled over it; and whilst other parts were overrun by the Mahrattas, his dominions continued to increase in prosperity and in population. In 1749 the son-in-law of Aliverdy Cawn succeeded, and he handed down the inheritance to his son. After various revolutions, the government devolved on an officer, Khadem Hussein, who engaged in a war with the British, but was finally obliged to retire to Oude. The principal towns are Purneah and Tajepore. The former is pleasantly situated on the eastern bank of the Seraw River, and carries on a considerable trade. Long. 88. 23. E. Lat. 25. 45. N.

PURPURE, in *Heraldry*. The colour so called, which signifies *purple*, is an engraving represented by diagonal lines from the left to the right.

It may serve to denote an administrator of justice, a lawgiver, or a governor equal to a sovereign; and, according to Leigh, if it is compounded with

Or,	it signifies	Riches.
Arg.		Quietness.
Gul.		Politics.
Az.		Fidelity.
Ver.		Cruelty.
Sab.		Sadness.

Purrah ‖ Putrefaction.

PURRAH, a town of Hindustan, in the province of Bengal, and district of Rajemahl. In 1353 it was a royal residence, the capital of Hyas, the second independent sovereign of Bengal, when it was taken by the Emperor Ferose. The city was much extended during the reign of Rajah Causa, the Hindu monarch of Bengal, who died in 1392. His son removed the seat of government back to Gour. Some of the ruins of this city still remain. It is ten miles north-east from Maulda. Long. 89. 9. E. Lat. 25. 9. N.

PURSER, an officer on board a ship of war, who receives the victuals from the victualler, sees that they be well stowed, and keeps an account of what he every day delivers to the steward. He also keeps a list of the ship's company, and sets down exactly the day of each man's admission, in order to regulate the quantity of provisions to be delivered out, and that the paymaster or treasurer of the navy may issue out the debursements, and pay off the men, according to his book.

PURVIEW, a term used by some lawyers for the body of an act of parliament, or that part which begins with the words "Be it enacted," as contradistinguished from the preamble.

PURULENT, in *Medicine*, something mixed with, or partaking of, pus or matter.

PUS, in *Medicine*, a white or yellowish matter, designed by nature for the healing and cementing of wounds and sores.

PUSTULE, a pimple, or small eruption on the skin, full of pus, such as the eruptions of the small-pox.

PUTEOLI, a town of Campania, so called either from its wells, there being many hot and cold springs thereabouts, or from the stench caused by sulphureous exhalations. It is now called *Puzzuoli*, and is pleasantly and advantageously situated for trade. In a very remote age the Cumeans made it their arsenal and dock-yard, and to this naval establishment they gave the sublime appellation of *Dicearchia*. The Romans were well aware of the utility of this port, and took great pains to improve its natural advantages. Nothing remains of their works but a line of piers, built to break the force of a rolling sea, and which are vulgarly called the *bridge of Caligula*, because that madman is said to have marched in triumph from Puzzuoli to Baiæ on a bridge, which however was a bridge of boats.

PUTIWL, a city of Russia, in the government of Kursk, the capital of a circle of the same name. It stands at the junction of the Putiwl with the Gem, and is a very ancient place, surrounded with pallisades. It contains nineteen churches, 1276 houses, and 10,500 inhabitants, who are occupied in refining saltpetre, making vitriol, and in other branches of internal trade. It is 890 miles from St Petersburg. Long. 33. 55. E. Lat. 52. 21. N.

PUTNEY, a parish of the hundred of Brixton, in the county of Surrey. It is four miles from London, on the south bank of the Thames, over which there is a bridge that unites it to Fulham. It is situated on a gentle elevation, many of the houses in it commanding pleasant views on the river. It contains many houses of noblemen and gentlemen within it, some of the first order, and with highly ornamented gardens. It was the birthplace of Thomas Lord Cromwell, of West, Bishop Ely his contemporary, and, at a later period, of Gibbon the historian of Rome. It was also the head-quarters of Oliver Cromwell's army. The population amounted in 1801 to 2428, in 1811 to 2881, in 1821 to 3394, and in 1831 to 3811.

PUTREFACTION is the natural process of decomposition, by which the elements of organic matter are made to enter into a different state of combination, and by which new products are formed.

Putrefaction has been generally considered as a species of fermentation, which has been divided into three kinds, the *vinous*, the *acetous*, and the *putrefactive*. The first is so termed, because during its progress spirit of wine is formed; the second, because acetum or vinegar is produced; and the last, because by it the substance runs into putrefaction. Putrefaction.

All animal and vegetable matter is liable to undergo putrefaction; certain circumstances, however, are necessary for the commencement and continuance of the process, as the presence of moisture and a due degree of heat.

With regard to the putrefaction of vegetable bodies, the substance first becomes mouldy, it then emits an offensive odour, and in the course of time is in a great measure consumed. That moisture is necessary seems evident; for if the vegetable be cautiously dried by the application of heat, it may be preserved for almost any length of time. Hence the heat at which it must be kept, so as to make it putrefy, must not be such as will expel the moisture. On the contrary, when the temperature is low, the putrefactive process is put a stop to.

The admission of air also favours putrefaction, by allowing the escape of the volatile products. Many vegetable substances, however, particularly those that contain a large amount of carbon, are not entirely consumed by putrefaction; there is left a substance called *vegetable mould*, which does not putrefy when excluded from the air, but soon does so when exposed to it.

Vegetable mould constitutes a part of the soil, and contributes to vegetation, provided it be exposed to the atmosphere; hence the necessity of turning up the soil to cause the putrefaction to go on, by which it is supposed the mould, during its decay, becomes soluble, so that it is easily taken up by plants, and thus affords them nourishment. But when this is not done, more particularly when the mould is in large quantity, it accumulates, and hence the origin of *peat* and *morass*.

Animal matter is also liable to putrefaction; indeed it decays more easily than vegetables, provided it be kept at the requisite temperature, which is between forty and eighty degrees; the nearer to the latter the better; and if below thirty-two it ceases. Moisture is also necessary, and the freer the admission of air, the more rapid is the decomposition.

The first appearance of putrefaction is a change of colour and of consistence; the matter becomes paler and softer, emits a disagreeable smell, and at the same time evolves gaseous bodies, the nature of which depends on that of the animal substance; but it in general consists of carbonic acid, sulphuretted hydrogen, and volatile alkali, the disengagement of which ceases in the course of time, and a dry hard mass remains, containing the fixed principles of the animal kingdom.

When, instead of being exposed freely to air, the matter is buried, the putrefaction goes on more slowly, especially when the earth is dry, because the moisture from the animal matter is extracted. When the air is completely excluded, the substance is not entirely destroyed; the elements, by their new state of combination, form a peculiar principle resembling spermaceti, which has been called *adipocere*, from its properties being intermediate to those of fat and of wax.

Various means are resorted to for retarding or preventing putrefaction, both of animal and vegetable matter. Perhaps the most efficacious is cold, which is supposed to act by causing the congelation of the moisture, and thus preventing the elements from entering into new states of combination. It is well known that vegetables and butcher-meat, when put into snow, may be preserved for almost any length of time; and hence the common practice of sending fish to a distance packed in ice; whilst in the northern regions the inhabitants are in the custom of laying up a store of provisions surrounded by snow, by which they are kept fresh till required.

Depriving organic matter of moisture is another mode of retarding putrefaction; and hence it is that, when the sub-

Putrefaction.

stance is exposed cautiously to heat, by which the moisture is expelled, the putrefactive process is prevented. Hence the practice of drying fish; and in some countries it is customary to cut flesh into thin slices and dry it, in which state it is kept until it be required.

As exposure to air promotes putrefaction, exclusion from it retards it; and this affords another method of preserving animal and vegetable matter. Hence the custom of rubbing eggs over with butter, and also of keeping them in lime-water. Butcher-meat, also, well packed in barrels, from which the air is completely excluded, may be kept fresh for a considerable time, and more particularly if the meat be *par-boiled* before it is packed. Strong soups, after being cooled, and of course congealed, are preserved during long voyages, by being put into earthen dishes, and in general covered with a layer of melted fat, and afterwards secured from the air by bladder or tinfoil. In many cases the meat is packed into tin boxes, the lids of which are afterwards soldered down so as to exclude the air. In this way meat has been taken to India and returned to this country as fresh as when put into the packages.

There are many substances which retard, indeed prevent putrefaction, and some of them, it is supposed, act by absorbing the moisture. The most powerful of these *antiseptics* is sea-salt, which, it is well known, is used largely in preserving meat, fish, butter, &c. Another substance which acts powerfully is pyroligneous acid; but it is generally allowed that it acts not by the acid which it contains, but by a peculiar principle formed during its formation, and in all probability similar to, if not the same as, that now called *creosote;* indeed it is also supposed that during the process of *smoking*, to which fish, and sometimes also meat, are subjected, the same principle is formed, and that it is this which acts in preventing putrefaction.

Sugar, it is well known, is also a powerful antiseptic, and hence its use in making preserves, &c.; so also is spirit of wine, and the volatile oils, as turpentine, which are much employed in preserving anatomical preparations.

Sir John Pringle made experiments to determine the powers of certain substances in promoting or preventing putrefaction. From these experiments he formed the following table, showing the relative antiseptic powers of the saline substances mentioned. Having found that two drams of beef put into a phial with two ounces of water, and placed in a heat equal to 90° of Fahrenheit's thermometer, became putrid in fourteen hours, and that sixty grains of sea-salt preserved a similar mixture of beef and water more than thirty hours, he made the antiseptic power of the sea-salt a standard, to which he compared the powers of the other salts. The algebraic character + signifies that the substance to which it is annexed had a greater antiseptic power than is expressed by the numbers.

Sea-salt, or the standard	1
Sal-gem	1+
Vitriolated tartar	2
Spiritus Mindereri	2
Soluble tartar	2
Sal diureticus	2+
Crude sal-ammoniac	3
Saline mixture	3
Nitre	4+
Salt of hartshorn	4+
Salt of wormwood	4+
Borax	12
Salt of amber	20
Alum	30

The quantities of spiritus Mindereri and of the saline mixture were such, that each of them contained as much alkaline salt as the other did neutral salts.

Myrrh, aloes, asafœtida, and terra Japonica, were found to have an antiseptic power thirty times greater than the standard. Gum ammoniacum and sagapenum showed little antiseptic power.

Putrefaction.

Of all resinous substances, camphor was found to resist putrefaction most powerfully. Sir John Pringle believes that its antiseptic power is three hundred times greater than that of sea-salt.

Chamomile flowers, Virginian snake-root, pepper, ginger, saffron, contrayerva root, and galls, were found to be twelve times more antiseptic than sea-salt.

Infusions of large quantities of mint, angelica, ground-ivy, green tea, red roses, common wormwood, mustard, and horse-radish, and also decoctions of poppy-heads, were more antiseptic than sea-salt.

Decoctions of wheat, barley, and other farinaceous grains, checked the putrefaction by becoming sour.

Chalks and other absorbent powders accelerated the putrefaction, and resolved meat into a perfect mucus. The same powders prevented an infusion of farinaceous grains from becoming mucilaginous and sour.

One dram of sea-salt was found to preserve two drams of fresh beef in two ounces of water above thirty hours uncorrupted, in a heat equal to that of the human body, or above twenty hours longer than meat is preserved in water without salt; but half a dram of salt did not preserve it more than two hours longer than pure water. Twenty-five grains of salt had little or no antiseptic quality. Twenty grains, fifteen grains, but especially ten grains only, of sea-salt, were found to accelerate and heighten the putrefaction of two drams of flesh. These small quantities of sea-salt also softened the flesh more than pure water.

The same learned and ingenious physician made experiments to discover the effects of mixing vegetable with animal matters.

Two drams of raw beef, as much bread, and an ounce of water, being beaten to the consistence of pap, and exposed to 90° of heat according to Fahrenheit's thermometer, began to ferment in a few hours, and continued in fermentation during two days. When it began to ferment and swell, the putrefaction had commenced; and in a few hours afterwards the smell was offensive. Next day the putrid smell ceased, and an acid taste and smell succeeded. Fresh alimentary vegetables, as spinach, asparagus, scurvy-grass, produced similar effects to bread on flesh, but in a weaker degree. From several other experiments, he found that animal substances excite the fermentation of vegetable substances, and that the latter substances correct the putrescency of the former.

By adding saliva to a similar mixture of flesh, bread, and water, the fermentation was retarded, moderated, but rendered of twice the usual duration; and the acid at last produced was weaker than when no saliva was used.

By adding an oily substance to the common mixture of flesh, bread, and water, a stronger fermentation was produced, which could not be moderated by the quantity of saliva used in the following experiment, till some fixed alkaline salt was added; which salt was found, without saliva, to stop suddenly very high fermentations.

Sir John Pringle did not find that small quantities of the following salts, sal-ammoniac, nitre, vitriolated tartar, sal diureticus, salt of hartshorn, salt of wormwood, were septic, as small quantities of sea-salt were. Sugar was found to resist putrefaction at first, as other salts do, and also to check the putrefaction after it had begun by its own fermentative quality, like bread and other fermentative vegetables. Lime-water made some small resistance to putrefaction.

Port wine, small beer, infusions of bitter vegetables, of bark, and the juice of antiscorbutic plants, retarded the fermentation of mixtures of flesh and bread; but an unstrained decoction of bark considerably increased that fermentation.

Puttan Somnant ‖ Puy de Dôme.

Crab-eyes accelerated and increased the fermentation of a mixture of flesh and bread. Lime-water neither retarded nor hastened the fermentation of such a mixture; but when the fermentation ceased, the liquor was neither putrid nor acid, but smelt agreeably. Flesh pounded in a mortar was found to ferment sooner than that which had not been bruised. The tough inflammatory crust of blood was found to be most putrescent; next to which the crassamentum, or red coagulated mass; and lastly the serum.

Dr Mackbride's experiments confirm many of those above related, especially such as show that the fermentation of vegetable substances is increased by a mixture of animal or putrescent matter; that the putrescency of the latter is corrected by the fermentative quality of the former; and that the putrefaction and fermentation of mixtures of animal and vegetable substances were accelerated by additions of absorbent earths and of Peruvian bark. He also found, that although unburned calcareous earths were septic, quicklime and lime-water prevented putrefaction, but that they destroyed or dissolved the texture of flesh.

The experiments of the author of the *Essai pour servir à l'Histoire de la Putréfaction* showed that metallic salts, resinous powders, extracts of bark, and opium, were very powerfully antiseptic; and that salts with earthy bases were less antiseptic than any other salts.

PUTTAN SOMNANT, a town of Hindustan, on the south-west coast of the Gujerat peninsula, and district of Puttan. Long. 70. 23. E. Lat. 20. 57. N.

PUTTY, in its popular sense, is a kind of paste compounded of whiting and linseed oil, beaten together to the consistence of a thick dough. It is used by glaziers for fastening in the squares of glass in sash-windows, and by painters for stopping up the crevices and clefts in timber and wainscots.

PUTTY sometimes also denotes the powder of calcined tin, used in polishing and giving the last gloss to works of iron and steel.

PUY, LE, an arrondissement of the department of the Upper Loire, in France, extending over 779 square miles. It has fourteen cantons, 117 communes, and 122,450 inhabitants. The capital is the city of the same name, distinguished by the addition *en Belay*, which is situated on the river Borne. It is the seat of the departmental boards of government, and the see of a bishop. It contains 2950 houses, with 13,100 inhabitants, whose chief employment is lace-making, and the manufacture of cotton goods, especially muslins. It has also some manufactures of copper and iron wares, and of pottery. Long. 3. 47. 40. E. Lat. 45. 2. 41. N.

PUY DE DÔME, a department in the south of France, formed out of the ancient province Lower Auvergne. It extends in north latitude from 45. 26. to 46. 11. and in east longitude from 2. 17. to 3. 54. In extent it is 3389 square miles, and is divided into five arrondissements, and these into fifty cantons and 438 communes, containing by the last census 573,100 persons. It is bounded on the north by the department of Allier, on the east by that of the Loire, on the south by the Upper Loire and the Cantal, and on the west by the Corrèze and by the Creuse. It is an elevated district, covered with hills and mountains, with few or no plains, but some beautiful valleys, not very wide, through which the streams flow. One of the most picturesque of these vales is that of Limagne, which extends along both banks of the Allier, from the entrance of that river into the department, to its passage out of it. It is remarkable for its fertility. The roads are planted with large walnut and elm trees, the sides of the hills are covered with vines, and on the tops are ornamented with towns, villages, and castles. Some of the mountains in the northern part, the highest of which reach to about 4000 feet, have marks of volcanic origin, and are composed of basalt or of lava. In the south the elevations are greater, and that called the Mont d'Or is about 6300 feet. The chief river is the Allier, which comes out of the department of the Upper Loire, is navigable in its course through Puy de Dôme, and receives the waters of various streams. There are several lakes in some of the districts, but none of them of any great extent. The climate is raw and variable on the mountains, but in the valleys it is mild, intensely hot in summer, and severely cold in winter; and occasionally most violent storms, accompanied with hail, are experienced in the most fertile of the valleys. The chief products, besides corn, of which there is a surplus for the supply of the neighbouring departments, are hemp, flax, wax, honey, fruit, especially cherries, walnuts, and wine. The last is abundant, but in general not highly estimated. The best is in the valley of Limagne; but even there the greater part of the produce of the vines is distilled into brandy. The nuts are so abundant that a great quantity of oil is made from them; and as fuel is scarce, many of the walnut trees are made use of for that purpose. There are mines both of iron and of coal, but they are not extensively worked. The manufactures are linen cloths, blond lace, silk stockings, some cotton, and thin woollens, ribbons, jewellery, leather, and paper. The population is so much beyond the means of employment, that a great number of labourers yearly go to the neighbouring department to procure work in summer, and return in winter with the wages which they have earned. The department elects four deputies to the legislature. It is in the diocese of Clermont, and under the judicial power of the courts of law at Riom.

Puzzulana ‖ Pyanepsia.

PUZZULANA or POZZOLANA TERRA, is a grayish kind of earth employed in Italy for building under water. The best is found about Puteoli, Baiæ, and Cumæ, in the kingdom of Naples, from the first of which places it derives its name. It is a volcanic product, composed of heterogeneous substances, thrown out from the burning mouths of volcanoes in the form of ashes; sometimes in such large quantities, and with so great violence, that whole provinces have been covered with it at a considerable distance. In the year 79 of the common era, the cities of Herculanum, Pompeii, and Stabia, although at the distance of many miles from Vesuvius, were nevertheless buried under the matter thrown out during these dreadful eruptions. This volcanic earth is of gray, brown, or blackish colour, and of a loose glanular, or dusty and rough, porous or spongy texture, resembling a clay hardened by fire, and then reduced to a gross powder. It contains various heterogeneous substances mixed with it. Its specific gravity is from 2500 to 2800, and it is in some degree magnetic; but it scarcely effervesces with acids, although partially soluble in them. It easily melts *per se*; but its most distinguishing property is, that it hardens very suddenly when mixed with one third of its weight of lime and water; and forms a cement which is more durable in water than any other. According to Bergman's analysis, a hundred parts of Terra Pozzolana contain from fifty-five to sixty of siliceous earth, twenty of argillaceous, five or six of calcareous, and from fifteen to twenty of iron. Its effects, however, in cement may perhaps depend only on the iron it contains. It is evidently a martial argillaceous marl that has suffered a moderate heat. Its hardening power arises from the dry state of the half-baked argillaceous particles, which makes them imbibe water rapidly, and thus accelerates the desiccation of the calcareous part; and also from the quantity and peculiar state of the iron and manganese which it contains, on which metals its properties chiefly depend. It is found not only in Italy, but also in France, in England, and elsewhere.

PYANEPSIA, in *Antiquity*, an Athenian festival celebrated on the seventh day of the month *Pyanepsion*, which, according to the generality of critics, was the same with our September.

Pycnostyle || Pylades.

Plutarch refers the institution of this feast to Theseus, who, after the funeral of his father, which happened on this day, paid his vows to Apollo, because the youths who returned with him safe from Crete then made their entry into the city. On this occasion these young men, putting all that was left of their provisions into one kettle, feasted together on it, and made great rejoicing. Hence was derived the custom of boiling pulse on the occasion of this festival. The Athenians likewise carried about an olive branch, bound with wood, and crowned with all sorts of first-fruits, to signify that scarcity and barrenness had ceased, and singing in procession a song. When the solemnity ended, it was usual to erect the olive branch before their doors, as a preservative against scarcity and want.

PYCNOSTYLE, in the ancient architecture, is a building where the columns stand very close to each other, only one diameter and a half of the column being allowed for the intercolumniations. According to Mr Evelyn, the pycnostyle chiefly belonged to the composite order, and was used in the most magnificent buildings; as at present in the peristyle at St Peter's at Rome, which consists of near three hundred columns, and in such as yet remain of the ancients amongst the ruins of Palmyra.

PYGMALION, in fabulous history, a king of Cyprus, who, being disgusted at the dissolute lives of the women of his island, resolved to live in perpetual celibacy; and making a statue of ivory, he fell so passionately in love with it, that, the high festival of Venus being come, he fell down before the altar of that goddess, and besought her to give him a wife like the statue he loved. At his return home, he embraced, as usual, his ivory form, when he perceived that it became sensible by degrees, and was at last a living maid, who found herself in her lover's arms the moment she saw the light. Venus blessed their union; and, at the end of nine months, she was delivered of a boy, who was named Paphos.

PYGMY, a person not exceeding a cubit in height. This appellation was given by the ancients to a fabulous nation inhabiting Thrace, who brought forth young at five years of age, and were old at eight. They were celebrated for the bloody war which they waged with the cranes.

PYKAR, a broker in India, inferior to those called *dallals*, who transacts the business at first hand with the manufacturer, and sometimes carries goods about for sale.

PYKE, a watchman in India, employed as a guard at night. Pyke is likewise a footman or runner on business. They are generally armed with a spear.

PYLADES, was a son of Strophius, king of Phocis, by one of the sisters of Agamemnon. He was educated together with his cousin Orestes, with whom he formed the most inviolable friendship, and whom he assisted to revenge the murder of Agamemnon, by assassinating Clytemnestra and Ægysthus. He also accompanied him into Taurica Chersonesus; and for his services Orestes rewarded him, by giving him his sister Electra in marriage. Pylades had by her two sons, Medon and Strophius. The friendship of Orestes and Pylades became proverbial.

PYLADES, an actor of pantomime, who was the first to bring that species of histrionics to a high degree of perfection at Rome. He was a native of Cilicia, and had been the slave of Augustus, who gave him his freedom. He was the rival of Bathyllus, but their mode of dancing was perfectly distinct; that of Pylades was full of dignity and of passion, whilst that of Bathyllus was of a more joyous character. Pylades even wrote a book on the principles of his art. For some reason or other he was banished from Rome, and his recall by Augustus was so palatable to the people that in their joy they forgot some severe measures which the emperor had passed. According to Suetonius, his banishment was caused by his having pointed with his finger to some one who had hissed his performance.

Pylos || Pyramid.

PYLOS, a city on the coast of Messenia, fifteen miles south of Cyparissia, is usually considered as the residence of Nestor, where he was visited by Telemachus. There were two other places of the same name, one in Elis, and another in Triphylia, which claimed this honour; but all the circumstances which the poet states suit best the city in Messenia. The quickness of the voyage between Ithaca and this southern Pylos is one of the principal objections; but it must be recollected that Athenë directed the vessel. Strabo, however, believed that the city in Triphylia, which seems to have been unknown to Pausanias, was the residence of Nestor; and he satisfied himself by the following reasoning. The description of Homer shows that the dominions of Nestor stretched on both sides of the river Alpheius; but this suits neither with Messenia nor with Elis. It was not upon the coast, for a messenger was sent to the ships to invite the companions of Telemachus to supper; and when Telemachus returned from Sparta he caused Pisistratus to drive his chariot directly to the harbour, so that the road to the harbour and city could not have been the same. The return of Telemachus to Ithaca is also brought forward as a proof, for he is made to pass Cruni, Chalcis, Pheia, and the coast of Elis, which, according to Strabo, he could only have done if he started from the Triphylian Pylos. Again, in the war of the Pylians against the Eleians, the time required to drive the booty, which consisted amongst other things of swine, was so short that they could not have reached the Messenian Pylos.

PYLOS, a city of Triphylia, was thirty stadia from Samicum, on the coast, and near a river once called Amathus and Pamisus, but subsequently Mamaus and Arcadicus. It was considered by Strabo as the residence of Nestor.

PYLOS, a city of Elis, eighty stadia from the city of Elis, was founded by Pylus of Megara, destroyed by Hercules, and rebuilt by the Eleians. It was situated between the sources of the rivers Peneius and Sellecis, and under Mount Scollis.

PYLSTART, an island in the Southern Pacific Ocean, about six miles in circumference, discovered by Tasman in 1643. Long. 175. 59. W. Lat. 22. 22. S.

PYRAMID, in *Geometry*, is a solid standing upon a triangular, a square, or a polygonal basis, and terminating in a point at the vertex; or it is a solid figure, consisting of several triangles, the bases of which are all in the same plane, and have one common vertex.

Pyramid is also applied to a colossal structure, corresponding in form to the geometrical definition of the solid, and remarkable not only for its magnitude and antiquity, but likewise for the mystery which still overshadows the object contemplated in its construction.

The number of pyramids scattered over Egypt, Nubia, and Ethiopia or Meroë, is very great indeed; but by far the most remarkable are those of Djizeh, Sakhara, and Dashour, on a plain to the north of Cairo, in Egypt. The first of these places, which is situated on the western bank of the Nile, and nearly in the latitude of Cairo, is distinguished above the others by possessing the three principal pyramids mentioned by Herodotus, and still justly numbered amongst the wonders of human art.

The largest of these pyramids, which goes by the name of Cheops (a Greek corruption of the Egyptian *Kobts* or *Copts*), stands on an elevation upwards of 150 feet above the subjacent plain, and rises to an altitude above the base of about 498 English feet. It is ascended by an uninterrupted series of steps, diminishing from four feet to two and a half in height, as the structure narrows towards the vertex. The breadth of each step is equal to its height. Upon the top there is a platform thirty-two feet square, consisting of nine blocks of stone, whereon travellers of all ages and nations have inscribed their names in their respective languages. This pyramid was explored, first by our country-

Pyramid.

man Mr Davidson in 1763, and afterwards with still greater success by Captain Caviglia in 1817. A full account of the adventurous explorations of each will be found in the article EGYPT, vol. viii. p. 547 *et seq.* of the present work. In all of the pyramids the entrances are in the north front, and the descending passages slope at an angle of twenty-six or twenty-seven degrees. This line seems to be nearly directed to the pole, and hence the northern face of the pyramid is almost in the plane of the earth's equator; a circumstance which goes far to show that the passages in question were intended for the purpose of astronomical observation.

The second pyramid, called that of Cephrenes, is stated by Denon to have a base 655 feet each side, and to be 398 feet in height. The pyramids are supposed to have been all coated or cased with stucco made of gypsum and flint; and in fact forty feet of coating still adhere to that of Cephrenes. But the great pyramid has no appearance of having been touched in this way; and on that of Cephrenes the coating was probably never completed, as no indications of it were discovered on removing the sand from its base. In 1816, Belzoni discovered the entrance in the north front of the second pyramid. Advancing along a narrow passage, he found that it terminated in a chamber at the centre of the pyramid, cut out of the solid rock, the dimensions of which he ascertained to be forty-six feet in length, sixteen in breadth, and nearly twenty-four feet in height. This chamber contained a sarcophagus of the finest granite, half sunk in the floor, with the lid drawn to one side and broken, and within were bones, supposed to be those of a bull, mixed with rubbish. An Arabic inscription on the wall proved that it had been explored by the curious of a former age. The dimensions of the pyramid were ascertained to be, the base 684 feet each side, the perpendicular height 456 feet, and the coating from the top to where it terminates 140 feet. (See the article EGYPT, *ubi supra.*)

The third pyramid, situated beyond that of Cephrenes, and called by the name of Mycerinus, appears to have been cased with granite, at least fragments of that material were found amongst the rubbish. But it still remains to be opened by some future traveller, Belzoni, with all his enterprise, having failed in the attempt. It is only 280 feet at the base, and 162 in height; and beyond it there is another of still smaller dimensions, having its summit crowned by one large block of stone, as if for a pedestal. The stability of these enormous piles was increased by the stones having been so fixed as to slope inwards, and the perfection of the adjustment may be inferred from this, that not one of them has yet swerved from its position. The structures raised by the ancient Egyptians were intended to last for ever.

The pyramids of Sakhara are three miles south of those of Djizeh, and the pyramids of Dashour are beyond those of Sakhara, whilst more of brick or of stone are scattered over the plain, intermixed with the excavations, cemeteries, and fragments of statues or edifices, which mark out the site of the second capital of the Pharaohs. Some of them are rounded at the top, and resemble hillocks cased with stone. One has steps like that of Cheops, the ranges, six in number, being twenty-five feet in height and eleven feet in width; and the total height is 150 feet. There is another, built also with steps or ranges, and not much inferior in altitude to that of Cheops. The stones of these pyramids are much decayed, and gradually crumbling into dust, evidently from great age. One of them is built of unburned bricks, containing shells, gravel, and chopped straw, and is altogether in a very mouldering state.

For some notices of the various opinions stated by travellers as to the purposes for which these extraordinary structures are supposed to have been intended, the reader is again referred to the article EGYPT in this work. The bones found in the chamber of the pyramid of Cephrenes, not to mention other circumstances, seem to have some connection with the worship of the sacred bull Apis; and besides, from the care with which the entrances appear to have been concealed, it is not impossible that there may yet be many undiscovered chambers, both in the pyramid of Cheops and in that of Cephrenes. It is very remarkable, too, that not a single sculpture or hieroglyph has been discovered in any pyramid which modern enterprise and research have yet explored. (A.)

Pyramidoid || Pyrenees, Lower.

PYRAMIDOID, a term which is occasionally employed to denote the parabolic spindle, or the solid formed by the rotation of a semiparabola about its base or greatest ordinate.

PYRENEAN MOUNTAINS, or PYRENEES, are the mountains which divide France from Spain, and are the most celebrated in Europe, excepting the Alps. They reach from the Mediterranean as far as the Atlantic Ocean, and are about 212 miles in length. They have different names, according to the different places where they stand. Mont Perdu, the highest of the Pyrenees, has an elevation of 11,283 English feet.

PYRENEES, EASTERN. The eastern extremity of the Pyrenees gives its name to a department watered by the Agly, the Tet, and the Tech, which flow in an easterly direction towards the Mediterranean Sea. It possesses a warm and genial climate, very favourable to the culture of the vine; but the lands near the sea are marshy, from which arise exhalations prejudicial to health. The chief towns are Perpignan, the seat of a prefecture and a diocese, on the right bank of the Tet; Elne, on the left bank of the Tech, the site of the ancient Illiberis, under whose walls Hannibal encamped; Foix, in the valley watered by the Ariège; and Saint Giron's, on the Salat, a small river, on which are several paper-mills and other manufactories. The extent of territory of the department is 209 geographical square miles. It is divided into three arrondissements, seventeen cantons, and 226 communes. The inhabitants in 1837 amounted to 164,325.

PYRENEES, *Upper*, a department of France, which derives its name from the highest part of the Pyrenees. It is formed almost entirely of the ancient country of Bigorre. From the plains in the confines of Gers, to Mont Perdu, the highest point of the department, is experienced every gradation of European climate. No great quantity of corn is raised, but the country abounds in wine. The shepherds who inhabit the mountains are an active and hardy race of men. The principal towns are, Vicq en Bigorre, on the right bank of the Lachez; Tarbes, on the banks of the Adour; Bagnères de Bigorre, remarkable for its mineral waters; Campan, which carries on a considerable trade in paper and woollen stuffs; Cauterets, not far from the summits of the Pyrenees, celebrated as the residence of Margaret of Valois. The thermal springs of Barèges vary in temperature from 106° to 122° of Fahrenheit. The department consists of 229 geographical square miles, divided into three arrondissements, twenty-six cantons, and 492 communes. The population in 1837 amounted to 244,170.

PYRENEES, *Lower*, includes part of Navarre and the ancient principality of Béarn. The Pyrenees do not occupy one half of the department, and do not rise to a great elevation. The heights are crowned with forests, and the valleys are fruitful and well peopled. The Bidassoa bounds the department on the west, and determines the line which separates the kingdoms of France and Spain. Near the extremity of the heights that command the fruitful valley watered by the Gave, stands Pau, a town of some elegance, celebrated as the birthplace of many extraordinary persons, amongst whom may be mentioned Henry IV., Gaston de Foix, the celebrated Duke de Nemours, and Joan d'Albert. Further down the river stands Orthés, renowned as the scene of a destructive battle fought at the gates of the town in 1814, where the Duke of Wellington purchased a victory

Pyrites || Pyrometer.

over Marshal Soult with the loss of 10,000 men. Bayonne, a place of considerable trade, and a strongly fortified town, stands at the confluence of the Nive and Adour, about two miles from the Bay of Biscay. The department contains 379 geographical square miles, divided into five arrondissements, forty cantons, and 630 communes. The population in 1837 amounted to 244,170.

PYRITES, a metallic substance, combined with sulphur; as iron pyrites, composed of sulphur and iron, and copper pyrites, of sulphur and copper. See MINERALOGY.

PYRMONT, a city of the principality of Waldech, in Germany, and the capital of the district of the same name. It is a well-built place, containing 320 houses, and 2400 resident inhabitants. It is chiefly remarkable for its mineral springs, which are much frequented in the summer months by invalids. It is situated at the northern extremity of a picturesque valley on the river Emmer. It is surrounded with pleasing groves and other public walks, as well as with all the accommodations which can contribute to the gratification of those who resort to its waters. The principal spring, called the holy well, has an intoxicating quality and a vinous spirited taste, and has long been the most celebrated of the steel waters. From this well more than 400,000 jugs are annually filled, and despatched to other parts of the world; and it is said to lose none of its qualities by the longest journey. There are other springs, of various component parts; and one from which a large quantity of culinary salt is made. The Prince of Waldech has a palace near the city, which was formerly occupied by Frederick the Great, who frequently had recourse to these springs in his latter years. Lat. 51. 59. 28. N.

Pyromancy || Pyrometer.

PYROMANCY, a kind of divination by means of fire.

PYROMETER.

INSTRUMENTS for ascertaining the effects of a given change of temperature on the dimensions of solids are named *pyrometers*, from *πυρ*, *fire*, and *μετρεω*, *I measure*. The same name is also given to such instruments as are employed for the converse purpose of inferring from some of the various effects of heat, temperatures higher than those to which ordinary thermometers are applicable. Both classes of these instruments have been constructed in a variety of forms; but, unless where the temperature was to be high, the most of them formerly acted on the principle of rendering the minute expansions sensible or appreciable by means of machinery. Accordingly, such an instrument generally consisted of an apparatus for producing the requisite change of temperature, coupled with machinery so contrived, that when to one part of it an imperceptibly small motion is given by the expansion of the substance under trial, a very sensible motion is thereby produced in another part. However, in almost no case can the machinery for increasing the sensibility be with safety or propriety exposed to any high temperature; and frequently the heat of a furnace is now inferred from or denoted by the fusing point of the particular metal, alloy, or other substance which it is just able to melt, such fusing points being supposed to be previously known. But the methods as yet employed to determine high temperatures, however useful some of them may be for recording particular intensities of heat, and showing when the intensity in one case is equal to that in another, are insufficient to indicate their absolute values, or in what ratio unequal intensities differ among themselves. Nay, even their values in terms of the common scales of temperature are as yet but very imperfectly known in the higher part of the range.

In most of the earlier pyrometers the substance under trial was heated by the immediate contact of the flames of lamps; a method which not only produced an entirely unknown temperature, but probably gave to different bodies, or even to different parts of the same body, very different temperatures. This was greatly improved upon by applying the lamps to a metallic trough or boiler, containing some liquid, in which the bar under trial and a thermometer were immersed. Sometimes an inner case or trough has been used to keep the specimen dry; and when only a very moderate heat is required, steam has also been used to heat the specimen. This, though generally supposed to be a recent application of steam, had, according to Mr Nicholson (*Journal* for February 1805), been used by J. H. de Magellan in 1784.

To obtain an appreciable indication of the expansions of bodies, Muschenbroeck, to whom we owe the first instrument of this sort, as well as the name *pyrometer*, made the expansion of a rod of the substance under trial move a toothed rack, turning a pinion fixed on the axis of a wheel, which again turned a second pinion on the axis of the index, and the latter revolved over a graduated dial. Some have added more wheels and pinions, or have used a system of levers, or one consisting partly of levers and partly of wheels and pinions; and did the accuracy keep pace with the sensibility, such instruments might be correct enough. Other contrivances for increasing the sensibility are very numerous, but they are generally so readily referrible to similar principles as to render particular descriptions of them unnecessary, more especially since none of them is free from the objections about to be stated. Smeaton employed one lever, and observed how many turns and parts of a turn of a fine screw, whose end was just in contact with a piece touching the lever, would make it be again barely in contact with that piece, after the bar under trial, and acting near the fulcrum of the lever, had undergone the requisite heating. Lavoisier and Laplace made the expansion of the bar under trial act upon one lever, which again acted on a telescope hung as a second lever. This telescope being directed to a large graduated scale placed at a known distance, the slightest deflection which the expansion of the bar under trial occasioned in the direction of the telescope was thus rendered very conspicuous. Had the accuracy of this mode of operating, therefore, been as great as the sensibility thereof, it would certainly have given the expansions to a great degree of exactness.

But the preceding kinds of pyrometers, however useful for exhibiting in a general way the expansions of bodies, or for illustrating the subject in a public lecture, are by no means entitled to much confidence; for, in using wheels and pinions, as well as levers, or any of these coupled with other machinery, there is always considerable uncertainty in the result, owing to the loose connection of the several parts, and their sometimes bending under the strain, as also to the friction and obliquity of action. Nay, an error of some consequence may even arise from the bar itself under trial being compressed by its giving motion to the machinery, more especially at the time when it is softened by heat; and those parts of the mechanism which touch the ends of the heated bar, and that in particular which is moved by its contact, will be apt to partake in its temperature, to an uncertain extent, and to occasion a corresponding uncertainty in the result.

Microscopic pyrometer.

The celebrated artist Mr Ramsden invented a method of measuring the expansions, as seen greatly magnified through microscopes, which is not only free from the uncertainties of the instruments just noticed, but is much

Pyrometer.

more manageable than they are. A particular description of the pyrometer which Mr Ramsden constructed on this principle, for ascertaining the expansions of the rods employed in measuring a base on Hounslow Heath for the trigonometrical survey, is given by General Roy, in the *Philosophical Transactions* for 1785; though, owing to the scarcity of letters of reference, the engraving must be nearly unintelligible to those who are not versed in such subjects. This apparatus appears to be susceptible of acting with great accuracy under moderate heats; but neither it, nor indeed any other instrument of the sort, seems directly applicable under very high temperatures, though we shall afterwards see how the microscopes may be rendered equally available for appreciating or measuring the expansions marked by register pyrometers, or those which, even after they have again become cold, preserve an indication of the extent of the expansion which has occurred during their previous exposure to a great heat.

We can only give here a very general description of Mr Ramsden's pyrometer, which consists of a strong deal frame, five feet in length, nearly twenty-eight inches in breadth, and about forty-two inches in height. The bar of the material whose expansion is to be measured, and which may be even two feet long, is placed with water in a copper trough or boiler fully five feet in length. Beneath this trough are set twelve spirit-lamps, whose flames may heat the water in the trough, and the bar placed therein for trial, to the boiling point, if required. But it is evident, that by filling the trough with a liquid having a higher boiling point, a still higher temperature might be attained. On each side of the copper trough, and parallel to it, at a little distance, is placed a wooden trough filled with water, and each of these contains a cast-iron prismatic bar. For greater simplicity, we shall suppose that there are also two cross pieces, which can be fixed anywhere on the cast-iron bars, and at right angles to them, and that each cross piece carries a microscope to look directly down upon each end of the bar under trial.[1] The one microscope has only a simple mark or point in its field of view; but the other is furnished with such a wire-micrometer as is described under the article Micrometer.

Whilst operating with this apparatus, it is of consequence that the temperature of the two cast-iron prisms in the wooden troughs should continue as steady as possible, which can be easily tested by placing thermometers beside them in the water; or a steady temperature may be insured by keeping the troughs filled with melting ice, as was done by General Roy. Suppose, now, the cross piece carrying the microscope which has the point in its field of view, to be so set over one end of the bar under trial, that this point or mark may appear directly coincident with the extremity of the bar to be examined, or with a point or mark near its extremity. In like manner, let the other microscope be fixed over the other extremity of the bar under trial, so that its moveable wire may be accurately coincident with the other extremity of the bar, or with a point or mark near it. These adjustments being made, suppose the temperature of the water and of the bar in the boiler to be exactly 32° Fahrenheit. By means of the spirit-lamps under the boiler gradually heat it to 140°, or any other required temperature, and look through the second microscope. As soon as the change of temperature begins to affect the length of the bar, the mark at its extremity will be seen to deviate from its previous coincidence with the wire of the micrometer, and to extend beyond it. On the bar, therefore, attaining any other temperature, we can measure the corresponding expansion which has occurred, by observing how many turns and parts of a turn of the micrometer-screw are necessary to bring the micrometer-wire into coincidence with the slowly shifting mark on the expanding bar; and as the value in parts of an inch of each turn of the micrometer-screw is accurately known, a direct measure of the expansion of the bar is thus obtained, free from the errors of a system of levers, or of a train of wheels and pinions.

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Adie's pyrometer.

A different form of microscopic pyrometer has been employed by Mr Alexander J. Adie;[2] in which, instead of the horizontal iron prisms of Ramsden, the microscopes are merely attached to an upright oaken post, which supports and holds nearly all the other parts, and which was made from such an old and thoroughly seasoned piece of timber, that it scarcely expands at all by heat. The bar or rod of the substance under trial is enclosed in a vertical tube, which again is surrounded by steam flowing in a continued current through an outer tube incasing the other. Both tubes are provided with small glass windows, for the purpose of viewing the ends of the included bar through the microscopes, and likewise for excluding the steam from the inner tube. By this means, the tendency which an accession of moisture has to increase the expansions of certain bodies is obviated. But although the inner tube may thus effectually protect the specimen under trial from the humifying influence of the steam, it by no means obviates the uncertainty of the effects of such humidity as that body may already contain. For it appears from Mr Adie's experiments, that as the temperature increases, the moisture, as might be expected, gradually evaporates from the bar under trial into the air which is enclosed with it in the tube. On this account, if the humidity remaining in the bar were constant, it might add to the expansion, but the gradual drying or evaporation of it tends to a contraction. Indeed, with respect to bodies which have their dimensions affected by a change of humidity, it seems very doubtful if the experiments with slender rods, the humidity of which is so easily altered, can be regarded as determining the expansion by heat of such blocks of the same substance as are massy, and have the humidity comparatively constant.

It is further to be observed, that in heating with steam, it only occasions an unnecessary expenditure of heat to allow a continued current, or indeed any quantity, of the steam to run waste or escape from the pyrometer, except as much as is sufficient at first merely to expel, through proper apertures, the air from the apparatus; after which the closer everything can be kept so much the better. It seems to have been owing to the employment of a continually escaping current, that Mr Adie found it difficult to maintain a temperature higher than 207° Fahrenheit; where-

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[1] In Ramsden's machine, the microscopes look horizontally; but their connection with the other parts is so complex that we could scarcely pretend to make them intelligible, without diagrams and a very long detail.

[2] Transactions of the Royal Society of Edinburgh, vol. xiii. p. 354, where it is described at great length, with an account of experiments, which, however, were made chiefly on building materials, from the temperature of 50° Fahrenheit, up to 207°. Some of the results are also given under the article Heat. It is neither said, nor is it at all likely, that the expansion of any of the stones which had a laminar texture was ever tried in the direction perpendicular to the scales or plates composing them. For the specimens being long slender slips or rods, their parts could scarcely have stuck together had their component plates run across. At any rate, the expansion was only tried in one direction, namely, in that which happened to lie in the length of the rod. But there is reason to think that, with the exception of brick, perhaps, and a few other amorphous bodies, almost every building material is likely to expand at different rates in its different linear dimensions. Such is known to be the case with certain bodies, particularly calcareous spar, which is said to expand in one dimension whilst it contracts in another. Now, since some of the marbles which had been heated in these experiments were found to have thereby acquired a permanent increase of length, we have been led to conjecture whether the caverns which abound in calcareous rocks may not be, in a great measure, owing to their having expanded permanently, but at different rates in their different dimensions.

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as, if sufficient care be taken to regulate the heat of the boiler, a single pipe connecting the boiler with a proper air-tight vessel in the pyrometer is all that is required, provided that pipe be sufficiently wide, and so inclined as readily to restore to the boiler all the water formed by the condensation of the steam. A regulating stop-cock may also be useful in the connecting pipe.

Deluc's compensating rods.

In order to ascertain the relative expansions of different materials for the construction of compensating pendulums, or what length of one material would by its expansion accurately compensate a certain length of another, Deluc suspended the one bar from an arm projecting horizontally from an upright deal plank; and the other bar he supported by resting its lower end upon a small cock or stage projecting from the lower end of the former bar. Whilst the first or hanging bar, therefore, expanded downward by heat, the second or standing bar expanded upward. A microscope was attached to the plank in such a manner that, while it was constantly supported by an horizontal arm, and directed horizontally to the standing bar, it could be shifted up or down the deal plank. When, therefore, heat was applied to the bars, and, by repeatedly shifting the microscope up or down the plank, a point was found in the standing bar which was neither raised nor depressed by the changes of temperature, the compensation was exact, or the respective lengths of the two bars (reckoning that of the standing bar from its base up to the immoveable point) were inversely as the rates of their expansions. The plank would remain nearly at the same temperature during the experiments, or it might be kept so by such means as are pointed out by the ingenious author, in his account of these and other experiments, described in the *Philosophical Transactions* for 1777. This method, however, Deluc owed to a hint which had been previously given him by Ramsden. A similar process has frequently been employed for testing and adjusting the compensation of the gridiron and other pendulums, after the parts are put together; namely, by finding when the position of a point in the pendulum, situated as near as can be found to the centre of oscillation, is not affected by a change of temperature.

Borda's measuring rules.

In the grand operation of measuring a base for determining the great meridian arc in France, Borda combined metallic measuring rods in such a manner, that they indicated directly of themselves, and with more certainty than could be done with thermometers, their own variations both of temperature and of length. A rule of platina twelve feet long was attached, by one of its extremities, to a rule of brass somewhat shorter, which rested freely on its surface, when placed horizontally. Towards the loose end of the brass rule there were traced on the platina rule very exact linear divisions, the parts of which were millionths of the total length of this rule. This end of the brass rule carried a vernier, whose coincidences with the platina graduations were observed with a microscope. Now the dilatations of the platina being much smaller than those of the brass for the same changes of temperature, the vernier of the brass rule behoved to be incessantly changing its coincidence from one division to another, according as the temperature varied. Borda availed himself of these changes to know at every instant the common temperature of these two bars, and also the ratio of the absolute expansions of the two metals. The values of the vernier divisions, in degrees of the thermometer, had been previously ascertained from noting the change which took place between first surrounding the compound bar with melting ice, and afterwards placing it in boiling water. It was therefore sufficient to read the indications of this metallic thermometer, in order to learn both the actual temperature of the bars in the atmosphere, and also what compensation was to be made in the measuring rods or chains, to reduce their lengths to what they should be at the standard temperature. But, after all, we suspect that if the upper of these rules was at any time more exposed than the lower to the aspect of the sky, it might be somewhat more cooled by radiation; and the sun, again, would have just the opposite effect of heating the upper more than the lower.

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Dulong's and Petit's experiments.

By means of a simple and ingenious process, Dulong and Petit compared the expansions of the volumes of several solid bodies with those of air and mercury. Having ascertained the absolute dilatation of mercury by heat in respect of the indications of an air-thermometer, from observing the unequal heights at which the mercury stood when at different temperatures in the two legs of an inverted glass syphon, they next measured the apparent dilatation of mercury in a glass tube. The difference gave them the absolute dilatation of the glass. Every kind of glass which they tried was found to dilate at the same rate; a result in which some are not disposed to acquiesce. The dilatation of iron, copper, and platina was determined by placing a rod of each metal of a known volume and weight in the axis of a glass tube shut at one end, and having only a capillary opening left at the other. The remaining space in the tube being then filled up with mercury, the tube was heated to different temperatures, and the quantity of the mercury noted which was in each case expelled from the tube. It is obvious that the volume of the mercury thus driven out is equal to the expansions of the mercury and of the solid metal, minus the expansion of the glass. With the exception of the groundless objections of Mr Crichton, which are noticed farther on, this method of Dulong and Petit is, so far as we know, universally acquiesced in; but since it merely gives the expansion of the volume, there is no reason to think that it can afford accurate data for estimating the linear dilatation of bodies; because it assumes that they expand at precisely the same rate in every direction, or in all their linear dimensions. Indeed, the greater part of the direct experiments on linear expansions which have been put on record, lose much of their value from involving this assumption; for it has been ascertained of certain bodies, that they expand very differently in their different dimensions; and probably something of the sort holds of most bodies. Nay, some are said to contract in one dimension, whilst they expand in another. Besides, every article which has been more or less compressed by having, whilst comparatively cold, undergone such operations as hammering, rolling, or wire-drawing, may, on after exposure to heat, be expected to acquire some permanent enlargement, and one too which, on account of the unequal compression, is likely to be very different in the different dimensions. Many fine astronomical and optical instruments we suspect to be liable to derangement from this source. Various cases of permanent expansions will be found noticed in the course of this article.

Achard's pyrometer.

Amongst the earlier attempts at ascertaining high temperatures, M. Achard constructed a pyrometer which is quite in the form of a common thermometer. The ball and tube are of semi-transparent porcelain, highly baked. They contain a very fusible alloy, consisting of two parts of bismuth, one of lead, and one of tin, which, though solid at low temperatures, becomes liquid about 212° Fahrenheit; and then, as the heat increases from that upward, it expands in the liquid state similarly to mercury, and is seen through the semi-transparent tube, which is graduated. There seems scarcely any limit to the temperature to which this kind of instrument could be extended, provided only a material could be got for forming a ball and tube which would both bear the heat and also admit of the liquid metal being seen through it. There would be no difficulty of finding a less fusible alloy; and were there no risk of its oxidation or evaporation, it might be put

Pyrometer. into an open though perfectly opaque tube, in which a float might indicate the extent of the expansion by its top rising above the open end. But it would still be desirable to ascertain, if possible, the value of the degrees of this and every other pyrometer, in terms of the common thermometer.

Air pyrometer. It is long since the expansion of air had been proposed by M. Schmidt as a measure of high temperatures. This was afterwards suggested by Dr Ure, and still later by Mr Mill, who proposed to employ for that purpose a differential thermometer having one ball and half the tube of platina, and the other ball and half tube of glass. The platina ball being put into the furnace, it is supposed that the instrument would indicate the excess of the heat within over that of the external air. Such might at first sight appear to be a very convenient pyrometer, but it stands greatly in need of improvement; because, unless for small differences of temperature, a differential thermometer cannot continue to give the difference of two thermometers indicating the temperatures of the respective balls. Neither can this method afford data for computing the temperature of the platina ball, unless the temperatures of the other parts were first accurately known, which is far from being the case. For although, to ascertain the temperature of the glass ball with tolerable accuracy, it would only require to be immersed in a bath along with a thermometer, which however could not be so easily done if the whole tube were straight, as proposed by Mr Mill; yet since a large proportion of the included air would necessarily be contained in the tube, it would be next to impossible to allow for its temperature, because that would vary through all the degrees intermediate between the temperatures of the two balls. Perhaps the most correct apparatus yet employed on this principle, and in which precautions are used to avoid the errors now mentioned, is that of Mr Prinsep, described farther on, for ascertaining the melting points of his pyrometric alloys, in terms of the scale of the common air-thermometer. But Schmidt's scheme, as described in Nicholson's *Journal* (vol. xi. p. 141), comes nearer the mark than any of the other two. Schmidt and Mill seem to have taken it for granted that a bulb of platina could be as easily formed as one of glass; but of this Dr Ure probably had some doubt; for he suggests that the platina might be formed into a hollow cylinder having the tube screwed in, like that of a tobacco-pipe. Perhaps the ends, too, might be screwed in. Mr Prinsep's bulb being of gold, could only be used at temperatures below the melting point of that metal.

The determination of the temperature of furnaces is an important question; but until nearly twenty years ago, when Professor Daniell took up the subject, the only instrument in repute for this purpose was Mr Wedgwood's pyrometer; "the indications of which," says Mr Prinsep, "are assumed in every chemical work as authority for some doctrines relative to the scale of temperature which savour of the marvellous, and for others which a slight practical acquaintance with metals and crucibles must at all times have proved to be fallacious." The principle on which this pyrometer depends is vague and uncertain in the extreme, namely, the permanent contraction of certain aluminous clays, when exposed to an intense heat. For it has been found, that the amount of the contraction, even of the same clay, so far from being in exact proportion to the intensity of the heat, as assumed by Mr Wedgwood, depends very much on the duration of the process, so that long-continued exposure to an inferior temperature produces as great a contraction as if the clay had been submitted for a shorter time to a more intense heat. This instrument has of course served its day, and gone into disuse. Pyrometer.

There are many igneous operations, such as enamelling, assaying, those of the foundery, &c. which furnish tests, of themselves, on which the workman can generally place considerable confidence, though some of these require to be used with great caution. Thus, the colour which heat produces on the surfaces of metals furnishes a somewhat deceptive criterion of the temperature or temper; because the particular colour depends very much on the duration of the exposure to the heat. For example, a piece of hardened steel may become quite blue, if long enough exposed to a heat which is too low to produce the supposed corresponding effect in tempering or reducing the hardness.

In the *Quarterly Journal of Science* (vol. xi. p. 309), Professor Daniell has described an ingenious instrument, of his own invention, with which he has ascertained the fusing points of various metals, and which has served to overturn the catalogues of high temperatures deduced by means of Wedgwood's pyrometer, and so long occupying a place, with standard authority, in every chemical work.[1] But from the journal just cited it has now become unnecessary to draw any further account of Mr Daniell's pyrometer, because he has since made great improvements upon it, as described by him in the *Philosophical Transactions* for 1830 and 1831, and in his revised version of the same in the *Philosophical Magazine* for 1831 and 1832. Daniell's pyrometer.

This instrument we regard as a very important one, but still labouring under several imperfections, and susceptible of great improvements, some of which will be particularly noticed, after giving a general description. It consists of two distinct parts: The register, which alone is to be exposed to the heat, and is also to preserve an indication of the expansion of the material under trial; and the scale, which is not so exposed to the heat, but only measures the expansion upon the register after the latter has cooled. The former of these, represented in fig. 1, Plate CCCCXIX. consists of a bar of blacklead earthenware A A, eight inches long, seven tenths broad, and of the same thickness, cut out of a common blacklead crucible. In this is drilled a hole B B, three tenths of an inch in width, and seven and a half inches deep; and about six tenths of an inch in length of the substance of this bar is cut away from its side next the open end at C C, by a plane running along the axis of the bore. When this blacklead register is held upright, and a rod of any material 6·5 inches long is dropped into the bore, it rests against the solid end; and then upon the top of this rod is set a cylindrical piece of porcelain D D, about 1·5 inch long, which Mr Daniell calls the index, and which, projecting into and beyond the open part, is firmly held to its place by a ring or hoop of platina, E E, which, passing round the blacklead bar, and over the piece of porcelain, is made to press upon the latter with any required degree of tension, by means of a small wedge of porcelain, F F, inserted between the bar and the platina ring. When the apparatus, so arranged, is exposed to a high temperature, the expansion of the rod under trial will obviously force the index D forward through a very small space, equal to the excess of its own expansion over that of the blacklead; and after the register has again cooled, the index will be left nearly at the point of greatest elongation. According to Mr Daniell, the exact indication of this amount is not in the least affected by any permanent contraction which the blacklead may undergo

[1] Some of these extravagantly high numbers had been previously questioned by Morveau, in the papers which he published on his very imperfect platina pyrometer, in the *Annales de Chimie* for 1803, tome xlvi., and in the *Mémoires de l'Institut* for 1808 and 1811.

Pyrometer. at a high temperature, because he assumes any such contraction to occur at the moment of the greatest expansion of the metal, and the index, in consequence, still to mark its point of farthest extension upon this contracted basis. We are not, however, so clear on this point; but admitting it at present, the problem would now consist in the accurate measurement of the distance through which the index has been shifted from its original position. For this purpose, the scale, fig. 2, is constructed of two rules of brass G G and H H, joined together at a right angle by their edges, and fitting square upon two sides of the blacklead bar A A, and of about half its length. From the end of this double rule a small bracket, I, of brass, projects at a right angle, and which, when the two sides of the rules are applied to the two sides of the register, is brought close to the shoulder formed by the notch cut away at its open end, and the whole may thus be steadily adjusted to the blacklead bar by three planes of contact. Upon the outside of this frame, another and much larger brass rule K K, is firmly attached to it by the screws L L. This rule, projecting beyond the frame, and being turned up at the end M, about half an inch, so as to bring that end opposite the cavity in the blacklead bar when applied to it, supports a moveable arm, N, exactly 5·5 inches long, turning, at its fixed extremity, upon a centre near M, and at its other end carrying an arc of a circle O O, accurately divided into degrees and thirds of a degree, whose radius is exactly five inches. At P, the centre of this arc, upon the arm N, and, of course, at the distance of half an inch from the other centre M, turns another lighter arm Q, whose length being five inches, equals the radius of the circular arc O O, and one end of which carries with it a vernier *a*, which moves upon the face of the arc, and thereby subdivides the former graduation into minutes. The other end projects half an inch beyond the centre, P; and at the exact distance of one tenth of the radius P*a*, and which equals the interval between the two centres of motion, it carries an obtuse steel point *b*, turned inwards at a right angle. This part of the apparatus may be regarded as a pair of proportional compasses attached to the end of the brass rule and frame, and whose longer legs N and Q, carrying the arc and vernier, are to the shorter, carrying the point *b*, as ten to one; and the opening of the shorter being regarded as a chord of a small circle, is enlarged in the same proportion by the longer, and measured upon a scale. A small steel spring *m m*, let into the larger arm N, is made to press upon a little pin *n*, in the smaller arm Q, so as to adjust the vernier *a* to the commencement of the graduation; and when forced back, it tends to restore it to its original position. A small lens *i* is represented as folded down, but may, by means of the joints *k* and *l*, be raised to be directly over the vernier, to facilitate the reading of the divisions which coincide.

In fig. 3, A is an iron tube about two inches in diameter, and closed at the bottom. B is a blacklead tube, closed at the top, and fitted into the mouth of the former one by grinding. C is a smaller blacklead tube projecting from the side of the latter, and likewise fitted in by grinding. The whole forms a kind of alembic, in which mercury may be easily boiled, without either loss, or annoyance to the operator, by the escape of the vapour. When the register containing a rod of some substance under trial was put within the iron tube, and the remaining space filled with mercury, the boiling of the latter served the purpose of a thermometer, showing when the temperature reached about 662° Fahrenheit.

When the expansion of any substance is to be ascertained, a rod of it is to be provided, of such dimensions as will suit the cavity of the blacklead register; and being placed therein, the porcelain index D is to be pressed down upon it, and secured in its place by the platina ring E and porcelain wedge F. The scale part is then to be applied by carefully adjusting the brass rules GG, HH, to the sides of the blacklead, and pressing the cross piece I upon the shoulder. Holding the whole together steadily in the left hand, the moveable arm Q should be so placed that the steel point *b* of the short arm may rest upon the end of the porcelain index D, against which it will be pressed with some force by the spring *m*; then, moving the arm gently forward with the right hand, the point *b* will slide upon the end of the index till it drops into a small cavity formed for its reception, and which is in a line with the axis of the rod under trial in the register and the centre M on the brass rule. The minute of the degree must then be noted, which the vernier *a* indicates upon the graduated arc. A similar measurement must be made after the register has been exposed to an increased temperature and has cooled again; and the number of degrees or minutes which the vernier may then mark, will, by a simple calculation from the known length of the radii and angle, give the length of the chord comprised between the original position of the point *b* and the point to which it has been shifted, namely, the distance over which the index has been moved by the expansion.

But the preceding description, which contains the substance of Mr Daniell's view of the matter, is by no means even theoretically correct in the mode of computing the extent of the expansion. For Mr Daniell assumes that the above-mentioned chord of the small arc intercepted between the two positions of the point *b*, is always accurately in the same direction with the axis of the bore in the blacklead; whereas nothing can be more evident than that it must be owing to mere chance if it is ever so at all. Nor do we know any direct method of insuring that the chord shall have that direction. The problem obviously requires that chord to be reduced to the direction of the bore; and its length so reduced may, in every case, be obtained from considering that it is equal to the sum or difference of the sines of the two arcs which measure the angular deviations of the short arm (or rather of the straight line joining the centre of motion and the point *b*) from being perpendicular to the direction of the bore. But it is obviously by mere chance if the two arcs happen to be equal, so as to have the sum of their sines the same with the chord of their sum, as they are always assumed to be by Mr Daniell. If the graduated arc had its zero placed so as to correspond to the perpendicular position of the shorter arm, the two required arcs could then be more conveniently read off. When these lie on opposite sides of the zero, it is the sum of their sines that is to be used; but should they happen to be both on one side, the difference of their sines is to be taken. But in place of using either sines or chords, it would be preferable greatly to increase the lengths of both arms; and then if sufficient care were taken to have the shorter arm as nearly perpendicular as possible to the direction of the bore, the arc itself comprised between the two positions of the point *b*, from its now subtending a much smaller angle, might generally be taken as the measure of the expansion.

Mr Daniell, as we have seen, though he admits that during an experiment a permanent change may occur in the length of the blacklead, yet alleges that his results are not affected thereby. But since it is in respect of the shoulder at the mouth of the bore as bearing against the bracket I that his measures of expansions are taken, it is evident that the position of the bottom of the bore in respect of that bracket, and consequently the position of the index D in respect of the steel point *b*, must be affected by the full amount of any permanent change in the length of the bore of the register. However, it is equally clear that, were the rules G and H made of sufficient length to admit

Pyrometer. of the bracket I being placed at their other end, and so as to hold against the closed extremity of the blacklead bar, any permanent change which may have occurred in the length of the latter at the highest temperature, except in the mere thickness of its bottom, would not affect the result. The effect of any change of temperature on the brass rules could easily be allowed for, were it at all worth appreciating.

It will now be sufficiently manifest, without farther explanation, that instead of using Mr Daniell's scale-part, the amount of the expansion, as marked on the register by the index, might be equally well ascertained by the turns of a fine screw, as in Smeaton's pyrometer; or, still more accurately, by means of the microscopes and micrometer, as used with Ramsden's pyrometer, and others of that sort. The expansion might also be approximately measured by putting the register and index transversely between two graduated rules about 8·4 inches apart, and very slightly converging; which is similar to the mode in which Wedgwood measured his clay pieces.

But we suspect that the porcelain index itself must be a source of very considerable error or uncertainty, if its rate of expansion be different from, as it most probably exceeds, that of the blacklead. For, although it is likely that some points of the porcelain and blacklead which were in contact at the highest temperature to which they have been exposed, will continue in contact during and after the cooling, yet we are left quite in the dark as to the situation of these points; and consequently, we have no means of appreciating the length of that part of the index whose expansion is concerned. Nay, a similar uncertainty must, in consequence, attach to the effective length of the blacklead register. By shortening the length of the index, these uncertainties might be expected to be lessened; but it is by no means clear how they could be entirely obviated, except, perhaps, by using an index and wedge which should expand at precisely the same rate as the register does. Could the platina ring be got slightly to hold upon the register without the aid of a wedge, but still in such a manner that all the parts of the ring would slide equally along the register by the pressure of the bar under trial, the ring itself might serve as the index. In that case, instead of cutting away any portion from the side of the register, it would be better merely to cut a longitudinal slit in it, running quite through the axis of the bore, for the purpose of receiving and making room for the motion of a rib to be fixed diametrically in the ring, and upon which the expanding bar under trial could act, so as to move all the parts of the ring equally along the register.

By keeping a rod of platina in the register, exposing it to heats of various intensities, and ascertaining in each case the excess of the expansion of the platina over that of the blacklead, Mr Daniell determined a variety of temperatures in terms of such excess, which, unfortunately, is always a very small quantity, that between 32° and 212° Fahrenheit being counted 180 degrees. These results, though incomparably nearer the truth than those obtained by Wedgwood's pyrometer, must still be more or less tainted with some of the various errors to which we have either already alluded, or which are about to be noticed. But as our limits will by no means admit of fully discussing all the calculations, and attempting to correct them, we beg to refer the reader to the originals; and shall only attempt such an account of the principal sources of error as will sufficiently show the truth and importance of our allegations, which are, besides, applicable to most English books treating on this subject.

In deducing the numerical results from the experiments made with his pyrometer, particularly in computing the expansion of blacklead, Mr Daniell avails himself of the expansions which Dulong and Petit had obtained by the method already noticed, and these he finds to correspond surprisingly with his own. But independently of the doubts already hinted regarding their linear expansions, this agreement, as we shall presently see, argues nothing in favour of either determination; because the comparison has been made through the medium of a serious mistake, as we shall now endeavour to explain. The results of Dulong and Petit just referred to are those of the expansion of mercury and of several solids, given in the *Annales de Chimie* for 1818 (tome vii.), and regarding which they inform us, that the degrees inserted in the first columns of the tables are the upper limits of intervals of temperature, which are each of them reckoned from the freezing point, or 0° cent. Thus, regarding their Table IV., which bears more immediately on the present question, and has 100° and 300° occupying the first column, we are told that it "contains the mean dilatation of iron, copper, and platina, taken at first between 0° cent. and 100°, and then between 0° and 300°." That is to say, the first line of these dilatations contains the 100th part of the whole expansion for the interval between 0° and 100° cent., and the second line the 300th part of the entire expansion for the interval between 0° and 300°. Indeed, it is either expressly mentioned or obviously implied in the course of the Memoir, that every one of their intervals which relate to the expansions in question, is reckoned from the freezing point, and none of them from any higher temperature.

Shortly after Dulong and Petit had published this account of their valuable researches on heat, a translation of it appeared in the Annals of Philosophy (first series, vol. xiii.); and prefixed to the same volume is a Historical Sketch of the Sciences for 1818, which, amongst other things, professes to give an abstract of the principal points treated by Dulong and Petit in the Memoir referred to. But most unfortunately, in this Sketch, which seems to have been hastily got up, the results of these learned foreigners have been sadly misconstrued as far as regards expansion. For the numbers they have given as the upper limits of those intervals of temperature, which are each of them reckoned from the freezing point, are in the Sketch (page xii.) taken as so many points of temperature, at each of which respectively the expansions of the several bodies for one degree, as recorded in the other columns of the tables, take place; a mistake so egregious, that it quite unhinges the thing altogether, because the expansion, instead of being, as in the original, the mean for the whole interval, is thus made to belong to its highest degree alone. Now it would seem to have been somehow or other from this Sketch that Mr Daniell had taken up his leading ideas of the question; at least he has adopted a very similar misconstruction; for, in his Table II., which he gives as equivalent to Dulong and Petit's Table IV. above mentioned, he has, in place of 300° cent. or 540° Fahrenheit, made the second interval to be only equal to the first, which is 100° cent. or 180° Fahrenheit, a sense in which similar temperatures are also erroneously used in the Sketch (p. xii.). The effect of this unfortunate oversight is to make the expansions of iron, copper, and platina, especially that of iron, much smaller in the higher temperatures than Dulong and Petit found them to be; although, for want of data, we can only compute the effect of the error with certainty on the whole interval of 540°, without separating that of the higher temperature from the lower. Thus, Mr Daniell, by means of his very laborious but erroneous mode of computing from the numbers of Dulong and Petit, makes the linear expansion of 6·5 inches of iron, from 32° to 572° Fahrenheit, to be only ·025841887 inch. But the expansion of iron in the unit of volume, as given by Dulong and Petit for that interval, or from 0° to 300° cent., is $\frac{300}{22700}$. Now, one third of this taken as the linear expansion, and

Pyrometer. multiplied by 6·5, becomes ·028634361 inch. The error or deficiency of the former value is therefore ·002792474, and this would require to be added to ·00878 (Mr Daniell's expansion of 6·5 inches of blacklead), which will increase it to ·01157. But even this last number, if otherwise correct, is still too small, because the expansion above 572° up to the boiling point of mercury, to which he carried that of the blacklead, ought to have been computed at some higher rate, but for which we have no data. Such are specimens of the very erroneous conclusions which the above unfortunate oversight has led Professor Daniell to draw from the experiments of Dulong and Petit.

It seems to be from the same source, the Historical Sketch, that at least nine tenths of all the excerpts or abstracts that have been written in English, of the experiments of Dulong and Petit, are scarcely one whit more correct than the preceding, as far as regards expansion; although we have met with no such misconstruction of them in any foreign work. That such errors were very prevalent in this country, had been briefly noticed by Mr Meikle in the Philosophical Magazine for September 1830; which, if not quite in time to have saved the paper which Mr Daniell inserted in the Philosophical Transactions of that year from the errors in question, must have been sufficiently so for the one of next year, and for his revised version of both afterwards given, with those errors entire, in the Philosophical Magazine. It is no doubt also from the Sketch (page xvii.), that in English books, the specific heat of platina, professedly from Dulong and Petit, is usually made ·0355 at all temperatures, and therefore often regarded as a remarkable exception to the general law; whereas, between 0° and 100°, the mean value should only be ·0335; the larger number ·0355 being the mean for the whole interval between 0° and 300°. But the Sketch contains various other inaccuracies; and some, like the one last noticed, occur also in the English translation of the Memoir.

In noticing the labours of Dulong and Petit, Professor Daniell regrets that those able experimenters had not corrected their final results as to what he considers an important error of calculation, supposed to have been pointed out by Mr Crichton, regarding the expansion of mercury, particularly as employed by Dulong and Petit in determining the expansions of glass and of several metals, in the manner which we have briefly described above. It is, perhaps, rather unusual for writers of eminence to adopt any correction of errors, however important or clearly pointed out; because the public are generally expected to imbibe whatever may emanate from such authorities, and to listen to no insinuations of their being incorrect. But the following considerations will, in a great measure, account for Mr Crichton's corrections not having been adopted:—1*st*, Though it does not seem to be generally known in this country, M. Petit, who had taken the most active part in these valuable researches, particularly in the mathematical investigations and calculations, had died nearly four years before Mr Crichton's paper appeared in the Annals of Philosophy for April 1824; so that M. Petit, who was a young man of great promise, has long been outlived by his senior and distinguished colleague, M. Dulong, whose recent decease science has now to deplore. 2*d*, We have nothing like satisfactory evidence that Dulong and Petit have, after all, employed the erroneous modes of calculation imputed to them; and we shall soon see that, in at least one of these, it is Mr Crichton himself who is in the error. To determine the expansion of mercury in glass, Dulong and Petit filled with that fluid a glass tube which had its open end drawn into a capillary tube; and on heating this from zero up to different temperatures, they weighed the corresponding portions of mercury which were expelled. But they have nowhere said, nor is it so much as even implied in their Memoir, that they held the increase of volume to be in the exact ratio of the weight of mercury expelled, which would be to neglect the expansion of the expelled portion itself. This, however, Mr Crichton assumes that they did; and he thence concludes that they have made the expansion of mercury in glass, when heated up from zero to 100° cent., to be too small in the ratio of 63·8 to 64·8. We have no data for determining how far this supposed error would affect the expansions of the solid bodies operated on by Dulong and Petit; though it would no doubt be to a much smaller extent than that resulting from the above errors, into which Mr Daniell has himself fallen, in the temperatures. However, we find that it would but very slightly derange the indications of a mercurial thermometer up to 300° cent., or 572° Fahrenheit. For example, if Dulong and Petit have been right, the series of centigrade temperatures on the common mercurial thermometer would stand thus: 0°, 100°, 203°·20, 307°·69; and if they have been wrong, 0°, 100°, 203°·25, 307°·82; we mean in respect of those on their air-thermometer taken as uniform.

The preceding is by no means the only error with which Mr Crichton charges Dulong and Petit. Besides other things of which we have no means of judging, he blames them for holding the volume of mercury expelled by heat from the glass tube, to be equal to the absolute expansion of mercury diminished by the expansion of the glass; which, however, is a thing so palpably true, that scarcely any reasoning can make it clearer than it is. But the extreme palpability of this does not prevent Mr Crichton from going on with a process of reasoning *sui generis*, from which he concludes, that the expansion of the glass is much smaller than the difference between the absolute expansion of mercury and its expansion in glass. Since in this Mr Crichton has, without doubt, deceived not only himself, but many of his readers, it may be useful briefly to show how it has been done. In the first place, he has sadly obscured his formulæ, by representing by unity each of two things of very different values, more especially since both enter into the same expression. The one of these is the expansion of mercury in glass, and the other the expansion of the glass alone. The like may be said of his using the term *co-efficient* to mean what other people would call a *denominator*, or, in some cases, a *reciprocal*. But his principal error is, that in order to correct the capacity or contents of the vessel for the expansion of the glass, he makes a deduction, not from its contents as expanded at 100° cent., but from its contents at the freezing point, or at least from 63·8 times what he now uses as the expansion of mercury in glass; and in the preceding part of his paper he had made the contents of the vessel at zero to be just equal to 63·8 times the expansion which mercury seems to undergo in a glass vessel, by being heated from zero to 100° cent. In this case, therefore, the error lies with Mr Crichton himself.

Prinsep's pyrometric alloys.

The principle of the method employed by Mr Prinsep[1] for ascertaining high temperatures, particularly those of furnaces, by means of the least fusible substance each can melt, has already been briefly alluded to, and differs very materially from that of Mr Daniell. The former, which we shall now describe more in detail, was, after trying various plans, fixed upon by Mr Prinsep, as possessing considerable claims to accuracy, and having the great advantage of being identifiable, as he styles it, at any time and in any part of the world. In other words, it can show

[1] Philosophical Transactions for 1828, p. 82.

Pyrometer.

when the temperatures or intensities in different cases are equal, though it cannot determine in what ratio unequal intensities differ among themselves. The fusing points of pure metals are determinate and constant; they also comprehend a very extensive range of temperature; and the unoxidable or noble metals, gold, silver, and platina, alone embrace a range from the comparatively low melting point of silver up to the high ignition of platina. There are, it is true, only three fixed points in this scale; but between these as many more as are requisite may be interpolated, by alloying those three metals, or rather any two of them together at a time, in different proportions, though the like by no means holds with every kind of alloys. When such a series as that now proposed has been once prepared, the heat of any furnace may be expressed by the alloy of least fusibility which it is just capable of melting. Besides the unity of determinations which such a pyrometer affords, several other advantages might be mentioned: 1*st*, The smallness of the apparatus, nothing more being necessary than a little cupel, containing, in separate cells, eight or ten pyrometric alloys, each of the size of a pin's head; 2*d*, the durability of these alloys, since the specimens melted in one experiment would need only to be flattened by the hammer to be again ready for action, because without some such change of figure it would be uncertain whether they had again been melted or not; and, 3*d*, the facility of notation, since two letters with the decimal of the alloy would express the maximum heat. Thus, S·3G might be used for an alloy of seven tenths of silver with three tenths of gold; and G·23P would express gold containing twenty-three per cent. of platina. As gold melts at a heat not very much above that required by silver, Mr Prinsep assumed only ten degrees between them, distinguishing each degree by a successive addition in the alloy of ten per cent. of gold to the pure silver; the tenth degree being of course denoted by pure gold. These alloys are easily made, and require no comment; but to suit more accurate researches they may be farther subdivided, preserving still, for convenience, the decimal notation. From the fusing point of pure gold up to that of pure platina, Mr Prinsep assumed 100 degrees, adding one per cent. of the latter metal to the alloy for each successive degree. Now, although the melting points of the alloys used by Mr Prinsep apparently bear some relation to the proportions of the pure metals employed; yet, since the melting point of every alloy does not so much as lie between those of its component pure metals, but in many cases is lower than either of them, it must be merely an accidental coincidence, should any of Mr Prinsep's degrees correspond to equal increments of heat. They will, however, as was before observed, always indicate the same intensity; and their absolute values, or even those in terms of the thermometer, being a matter rather of speculation than of practical interest, are to be sought for by other expedients, such as comparing the expansions of a bar of platina with the fusing points of the alloys.

The following are a few trials which Mr Prinsep made with his pyrometric alloys in different furnaces and in different parts of the same furnace. The disparity of heat is greater than might have been supposed; and where, as in assaying the precious metals, so much depends upon the exact temperature at which that operation is performed, it would be useful to know every difference in this respect obtaining in various countries, and its effect upon the quality or standard of bullion. The temperatures are denoted by the least fusible alloys melted in the several cases.

Muffle of an assay furnace, front.....S·0G
Muffle of an assay furnace, middle, average.....S·3G
Muffle of an assay furnace, behind, average.....S·5G
Calcutta charcoal, being better than that of Benares, heats the muffle to.....G·04P
Calcutta silver-melting furnaces, of English construction, the specimens being in an iron pot....G·075P
Calcutta open native furnace.....G·06P
Calcutta blast-furnace, for melting musters.....G·2P
Blacklead table-furnace without chimney.....G·08P
Apex of condensed air blowpipe flame.....G·2P
Melting point of copper by two trials under a muffle...G·03P
Melting point of cast iron, about.....G·3P
Highest heat of a forge with the charcoal of Benares.....G·55P

Pyrometer.

Mr Prinsep says he lays little stress on the melting points of copper or iron, owing to their being tried on such a small scale. The alloys of gold and silver lose in weight by exposure to heat; but they are easily replaced, as the gold may always be again purified. The platina alloys are very durable, but they sometimes gain in weight. Mr Prinsep enters at considerable length into an examination of the changes which the composition of the alloys underwent by repeated fusion; but whether, or to what extent, their melting points may be altered thereby, is a question never once mentioned, though of incomparably more importance to the present subject.

Having explained the means which Mr Prinsep had provided for ascertaining the relative heat of a furnace, we turn to the more interesting portion of his experiments on pyrometric subjects, namely, the determination of the melting points of pure silver, and of its alloys with gold, in degrees of an air-thermometer. But we shall begin with the description of the apparatus employed, which at last satisfied his expectations, and furnished the results presently to be enumerated. In fig. 4, Plate CCCCXIX., it is shown in full operation. A represents a retort or bulb of pure gold, weighing about 6500 grains, and containing nearly ten cubic inches of air. B is a tube also of pure gold, which at its outer end is firmly joined by a small gold collar to a similar tube C, of pure silver; the bore of the latter tube is larger than that of the gold; but to prevent any undue influence from the unequal heating of the air contained in them both, and to confine the operation as much as possible to the gold bulb, the two tubes are nearly filled up by putting in wires of the same metals, so as to leave only a very minute crevice for the air to pass. The outer part of the tube C is kept cool with a wet towel, to protect the stopcocks and flexible tube D. This tube D completes the communication of the air bulb with the glass reservoir E, which is intended as a substitute for an inconvenient length of graduated tube. This reservoir is at first nearly filled with olive oil, and is furnished with a safety tube and bulb F, into which the oil rises when the air of the retort A begins to flow, and has a stopcock below, for the purpose of restoring the equilibrium of pressure, by drawing out a portion of the oil. In the collar of the reservoir E, however, there is another stopcock aperture leading into a graduated glass tube G, in which a small bubble of oil is made to traverse. As this tube was very accurately divided into 200ths of a cubic inch, and may be read off to a tenth of that quantity, the equilibrium of the pressure is capable of very delicate adjustment. The furnance, as the figure exhibits, was situated behind a wall in an adjoining apartment, so as to screen the exterior apparatus entirely from the heat. A small thermometer in the bulb F, however, serves to note any minute change of temperature in the reservoir E. The furnace and muffle need no description, being of the ordinary assay construction. The little pyrometric cupels *p*, *p*, *p*, contain alloys of silver and gold, as already described. Fig. 5 represents one of these cupels on a larger scale, with the lid raised, showing three of the alloys melted, and the rest retaining their previous form.

Out of the numerous experiments which Mr Prinsep made with this apparatus, we have selected the few follow-

Pyrometer.

ing results; but for the full details of these and many more, we beg to refer to the original description, where they are given at great length.

No.	Inches.	Inches.	Degrees.	Degrees.	Degrees.	Cupel.
1	7·472	10·410	1492	90	1582	...
2	7·559	10·430	1578	95	1673	...
3	7·106	10·370	1239	95	1334	...
4	7·643	10·442	1644	94	1738	...
5	7·775	10·465	1771	90	1861	S
6	7·620	10·440	1627	91	1718	S
7	7·901	10·480	1917	94	2011	S·4G
8	7·717	10·460	1727	84	1811	S
9	6·876	10·350	1110	84	1194	...
10	7·851	10·475	1863	90	1953	S·3G
11	7·915	10·480	1934	90	2024	S·2G
12	7·836	10·470	1845	85	1930	S·1G
13	7·936	10·490	1959	86	2045	S·3G
14	8·088	10·158	2426	88	2514	S·7G

The second column is the volume, in cubic inches, of the air expelled from the gold bulb, after all corrections. The third gives the contents of the heated gold bulb. The fourth contains the expansion converted into degrees, at the rate of three eighths for 180 degrees. The fifth column shows the temperature of the air. The sixth is the heat of the furnace, being the sum of the fourth and fifth. The seventh shows the heat of the furnace by the pyrometric cupels. The heat, in No. 1, exhibited an orange colour; in No. 2, bright orange; No. 3, bright red; No. 4, bright orange; No. 5, silver wire melted; No. 9, full red heat; No. 10, fresh air was put into the gold bulb; and in No. 11, the cupel at the back of the bulb was S. 3G.

From the construction of the apparatus, it must be evident that the temperature is to be deduced from the measured volume of air expelled from the heated gold bulb; which volume, again, is to be found by the weight of the oil drawn from the reservoir, together with the adjustment of the bubble of oil in the graduated glass tube. The necessary calculation, however, embraces several corrections, some of them of minor effect, and of known and certain influence, as the formulæ for barometrical and thermometrical change, specific gravity of the oil, &c.; others which may affect materially the results, and are by no means so certain in their power, such as the expansion of gold at high temperatures, and the absolute law of gaseous expansion. This last has been treated at considerable length under the article HYGROMETRY (vol. xii. page 114). At high temperatures a very small difference in the quantity of air ejected produces a considerable change in the corresponding temperature; in other words, this air-thermometer has the disadvantage of becoming less sensible, in respect of the scale of the common thermometer, with every increase of heat; for the portion of air which is expelled from the hot bulb must necessarily be cooled to a known point before it can be measured.[1] But this objection, which was started by Mr Prinsep himself, does not apply to his apparatus in respect of a scale of temperature graduated on the idea that air expands in geometrical progression for equal increments of heat, as it has been shown to do in the article just cited. The substitution of a reservoir of oil or mercury in place of a mere graduated tube, is essential where the instrument is to be suddenly thrust into the fire, as the rapid motion of a bubble of liquid in a tube would either, if of oil, leave it as a film lining the tube, or, if of mercury, allow a passage for the air past the side of it. The capacity of the reservoir employed by Mr Prinsep was equal to that of a tube 50 feet long, and of the same bore as the adjusting tube G. But it is evident that a bulb of gold can only be used at temperatures lower than its own melting point, so that the temperatures for the less fusible alloys are left undetermined.

Pyrometer.

In the course of his pyrometric researches, Mr Prinsep repeatedly found that, on heating a cast-iron retort from 80° up to 1800° Fahrenheit, it had, even after having again become cold, acquired each time a permanent enlargement, which, by three successive heatings, amounted to fully a ninth part of its original capacity. Each successive increase, however, was so much less than the preceding, that the first heating did nearly as much in that way as both the other two. It does not appear to have occurred to Mr Prinsep that there is any connection between such an augmentation of volume and the expansion which occurs in the solidification of iron at the casting of it; but we shall now endeavour to show, that they are just parts of one and the same process. It is curious, that in almost every book in which the expansion of iron in congealing is mentioned, it is, without giving so much as the shadow of reason or evidence, said to be momentary or instantaneous. But in many of the innumerable forms of the castings of iron, we have often observed cases occurring which cannot be reconciled with its momentarily expanding in the act of solidification, unless it also continue to expand considerably as long as it is kept very hot; and more especially unless the parts which were first congealed continue to expand whilst they remain in contact with any of the liquid metal. This impossibility of reconciling the phenomena with a momentary expansion is particularly remarkable, when in the structure of the article cast there occurs a massy nucleus of metal with arms or leaves of more slender dimensions proceeding from it. In that case, the interior of the nucleus is generally the last in congealing, and if so, it is almost never quite sound, there being always a deficiency of metal to complete such part of the casting as is last in congealing, which occasions it to be of a spongy texture, and, perhaps, to have cavities in it of a very different sort from those which are really owing to mere air-bubbles. Sometimes a cavity is open through the surface, which may be owing to its occurring so near the outside that the thin crust is depressed or broken quite through by the atmospheric pressure. When a hole is cast through the middle of a massy part of the iron, by means of a previously dried core, the metal next the hole is generally amongst the last in congealing, because such a core has almost no tendency to cool it; and, therefore, owing to the foresaid deficiency of metal, the hole where it passes through the interior is usually wider than the core, and, perhaps, has one or more cavities branching off from it.

Permanent expansion of cast iron; its connection with the expansion at casting.

Such cases as have now been instanced are of very common occurrence; but to some people they have appeared so very paradoxical as to lead them to deny that any expansion whatever can occur during the casting. At first sight, the sponginess and cavities might, no doubt, be easily accounted for, as some have pretended to do, by supposing iron to *contract*, instead of *expanding*, at the time of congealing. But that an expansion really occurs on that occasion, is so well attested[2] as to be placed beyond any doubt; and, therefore, such expansion, taken in connection with the preceding facts, and the important one noticed by Mr Prinsep, leaves us no alternative but to conclude, that the final deficiency of metal is owing to the exterior crust having; after its own formation, continued to expand, and thereby

[1] "That the air-thermometer," says Mr Prinsep, "cannot be expected to give indications perfectly accordant, those who have kept registers of the sympiesometer will be ready to grant." But the case of the sympiesometer furnishes no authority on the subject; because one very good reason for its own incongruities is to be found in the faulty mode of correcting it for temperature, which is such that its indications can never keep pace with those of a good barometer, even were it liable to no other objection.

[2] Particularly by Mr Mushet, in the Philosophical Magazine, vol. xviii. p. 1, first series.

Pyrophorus ‖ Pyrotechny.

to acquire a greater capacity within than the mere expansion of the interior parts at the time of their congelation enables them to fill up.[1] The sponginess and cavities which so often occur in the texture of the iron in the interior parts of an unbored cannon, and in those of shot, seem readily referrible to the same source.

Water and iron are usually supposed to follow similar laws of congelation, but their phenomena are certainly very different; for water, in place of continuing to expand, as iron may do, for an indefinite time, seems to cease to expand as soon as it assumes the solid form. We have often observed, that on exposing water in a thin vessel during intense frost, the exterior parts congeal first all around, next the vessel as well as on the top, so as to incase completely the remaining liquid with a crust of ice, which at length bursts, perhaps the vessel too, and part of the water escapes through the fissures. This no doubt is owing partly to the atmospheric pressure having prevented such crust from ever being larger than just to contain the water, and partly to the interior parts expanding subsequently to the crust having ceased to expand; so that, in place of a deficiency, there is here an excess of material within. On the contrary, nothing like bursting ever occurs in the case of iron; though frequently it happens that its more slender parts, in cooling, crack or break spontaneously, from their not having been able to preserve a temperature sufficiently high to continue the permanent part of the expansion so long after congelation as the rest has done, and also from their contracting sooner than the rest by the more sudden cooling. That the temporary part of the whole expansion which obtains in cast iron at a high temperature, is so great as to exceed the permanent part, appears from the subsequent contraction which occurs in cooling, as displayed by the well-known fact, that any lengthy casting is always sensibly shorter than its pattern; notwithstanding that the walls or inner surfaces of the mould, especially when formed of soft materials, have, by yielding to the weight of the liquid iron, and to the just-mentioned permanent part of the expansion, made room for some addition to all the dimensions of the pattern; so that the breadth, thickness, or such other of these dimensions as are small, generally exceed the corresponding ones of the pattern. From Mr Prinsep's experiments, however, we may learn the very important caution, that after trying to what extent any substance has been expanded whilst hot, it should also be ascertained whether any of its dimensions have thereby undergone any permanent change. Some of the stories so often repeated regarding remarkable exceptions to the general laws of expansion, are very likely referrible to this kind of source. Thus, glass vessels have sometimes been observed to acquire a permanent enlargement by long exposure to heat; and, in many researches, such a change in the vessel is apt to be mistaken for one of the opposite sort in any fluid it may contain. The case noticed by Mr Prinsep being that of a little iron retort, the mass would be small and the metal thin; and, therefore, at the time it had been cast, it must have cooled so soon that it could then have had almost no opportunity of continuing to expand permanently after its solidification. Hence, on being afterwards heated by Mr Prinsep, it would likely be in a state to expand so much the more. For, supposing the volume to undergo no change from oxidation or other chemical action, it is probable that long-continued annealing at a high temperature would give to cast iron a volume which it would not afterwards exceed, unless exposed to a still greater heat. On this principle, it might be supposed that a sufficient annealing might expand all the parts in the same ratio, and thereby ultimately fill up all the vacancies of the interior; but the rigidity of the iron puts this out of the question; and at any rate, granting that the annealing did bring the parts quite close together, they would not likely be united by cohesion at a heat so far below that required for welding.

Pyrotechny.

The preceding view of the subject, we presume, will be found to trace to a common source, and thereby to reconcile in a satisfactory manner, the various phenomena above mentioned, which depend upon the permanent expansion of cast iron, and have so often been regarded as paradoxical. The continued enlargement of the crust is most probably owing to some change of texture or arrangement, such as crystallization occurring not only, as is usually supposed, at the instant of congelation, and perhaps, too, before it, but continuing to go on in the solid part of the iron for a long while after, if it be kept sufficiently hot; and the nature of the mould very likely modifies this result, as it certainly does several others. Thus, a piece of iron cast in a metallic mould, being more suddenly cooled than if cast in sand, is much harder, and has, besides, a very different texture. But whilst it is not improbable that the contact of the metallic mould may be equally or more favourable to a particular arrangement of the particles, such process will be so much the sooner stifled by the more sudden cooling. As to wrought iron, its fracture sometimes exhibits a crystalline texture, which is a particularly bad symptom of its strength, but one, perhaps, which may have some connection with a permanent expansion. Bismuth and antimony are known to expand at the time of congealing; but how closely in this respect they may resemble cast iron, has not, as far as we know, been ascertained. (E. E. E.)

PYROPHORUS, formed of πυρ, *fire*, and φερω, *I bear*, the name usually given to a chemical preparation which possesses the singular property of kindling spontaneously when exposed to the open air, or when breathed upon. There are various kinds of pyrophorus.

PYROTECHNY, from πυρ, *fire*, and τέχνη, *art*. The usual modern meaning of the word is the art of making fireworks, and of disposing them to the best advantage when exhibited on occasions of rejoicing, or in theatres, gardens, and other places. A moment's consideration will show how very comprehensive a term *pyrotechny* may become if extended to all operations in which the skilful management of fire is required. It was anciently confined chiefly to alchemy, or incipient chemistry.[2]

Under the term pyrotechny we may properly enough include the making of the different sorts of gunpowder, and the preparation of all those combustible or detonating materials and projectiles used in war; but then it should be distinguished by the adjunct *military*. Military pyrotechny will then serve only to indicate a portion of one of the

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[1] Mr Prinsep not only never hints at there being any connection between the expansion which occurs in casting, and that which he observed; but the following quotation from the Philosophical Transactions for 1828, page 87, besides being curious, and the only remark he has made on the subject, sufficiently shows that he had no idea of the nature of the latter increase. "The augmentation," says he, "which is more remarkable, exceeds the dilatation due to the temperature to which it was exposed; for as iron expands ·0105 in 180 degrees, the increase of bulk upon 10 cubic inches should be ·105 × 3 = ·315 at 1800° Fahrenheit, or near the melting point of silver; whence it may be concluded that the dilatation of iron is not equable, as has been also proved by Messrs Dulong and Petit." We shall only add, that the experiments of these distinguished foreigners having been made on wrought iron, it is very doubtful if they bear on the question of permanent expansion.

[2] See Davidson's *Philosophia Pyrotechnica*, &c. 1635; and G. Starkey's Pyrotechny Asserted and Illustrated, &c. 1658.

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most deplorable arts ever invented, that is, the art of war. The miserable necessity of this art is, however, a matter of daily experience in the present state of human nature and unsocial relations; also the unhappy and slavish condition of all nations which are not able, by skill in this diabolical art, to resist effectually the aggressions of their invaders.[1]

We do not mean to give an account of the various substances, mixtures, and manipulations necessary in the construction of different fire-works; but, for the reader's amusement and instruction, we shall mention a few things which are not generally known, and then conclude with the titles of a few works upon pyrotechny.

The combinations of the different substances employed in the pyrotechny connected with fire-works ought to be guided by a chemical knowledge of these substances. The want of this knowledge causes most of our fire-workers to compound ineffective mixtures, and to follow old and absurd recipes. Great skill in pyrotechny, in its more general sense, was possessed by the Chinese long before the art was known in Europe. The invention of gunpowder seems to be due to them, and perhaps also the invention of fire-works. All those persons we ever conversed with who had been in China, concurred in assuring us that the Chinese fire-works are at this day quite unrivalled in variety, splendour, and beauty. In the account of Lord Macartney's Embassy to China there is an amusing passage describing the contempt of the Chinese for the best English fire-works that were exhibited to them, and the astonishment of the embassy on witnessing the superb display of fire-works given by the Chinese in return. The most imposing exhibitions of European fire-works used to be those that took place annually at Rome, during certain holidays, on the ramparts of the Castle of St Angelo.

We shall now give a very few notices of practical pyrotechny.

Lightning.—The fine seeds of the *lycopodium clavatum*, or common club-moss, are extremely inflammable, and are used in theatres to imitate a vivid flash of lightning, by blowing them from a tube, &c. through the flame of a lamp, &c. These seeds are also used in the composition of some fire-works.

Red Fire.—The nitrate of strontia is the chief ingredient in the composition. A beautiful purplish flame is produced by a composition containing chlorate of strontia. To aid in reddening the flame of the former composition, a little lamp-black of the finest quality is generally used; for a red jet of fire from a paper-case formed like that of a serpent, or of a Roman candle, &c., fifteen parts of pulverized gunpowder and four parts of dry nitrate of strontia; a slow and bright-red fire, forty parts of nitrate of strontia, thirteen of pulverized sulphur, five of chlorate of potash, and four of sulphuret of antimony. In this last mixture, to avoid the danger of premature combustion, the chlorate of potash must not be ground in a mortar with the other ingredients, but ground separately, and afterwards mixed with them by shaking and stirring upon a sheet of paper.

Green Fire.—Seventy-seven parts of nitrate of barytes, thirteen of pulverized sulphur, five of chlorate of potash, three of charcoal in powder, and two of pure arsenic. The same precautions to be taken as before with regard to the chlorate of potash. The effect of this composition, when burned on the stage of a theatre, is to give a cadaverous and unearthly aspect to the actors. It occurred to us many years ago, that an extension of some of the effects of De Loutherbourg's *Eidophusikon* might be easily and effectively adapted to the stage. Where the foot-lights are, or else above the proscenium or front of the stage, an apparatus might be contrived to throw variously-coloured lights upon the actors and the scenery in the representation of magical incantations, supernatural appearances, &c. The disposition and reflection of these variously-coloured lights might be diversified in such a manner as to produce the most singular contrasts and unexpected effects.

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Brilliant and sparkling jets of Fire.—These are produced from compositions rammed into paper-cases of various sizes. One of these compositions may consist of eighteen parts of pulverized gunpowder, five of bright steel-filings, and two of saltpetre; another of sixteen parts of pulverized gunpowder, seven of steel-filings, one of saltpetre, and one of sulphur.

Sparks.—The composition for these is mixed with pure alcohol. Small pellets of cotton are steeped in this mixture, and dried, after rolling them in pulverized gunpowder.

Stars.—Very brilliant stars, such as we see issue from sky-rockets, Roman candles, &c., may be made from a composition of one part of alcohol, one of antimony in powder, two of pounded crystal, one of gum-arabic, two of pulverized gunpowder, fifteen of saltpetre, six of sulphur, and two of zinc-filings. The composition for these and other stars is made into a stiff paste with alcohol, and then cut into small cylindrical or square pieces, which are rolled in pulverized gunpowder, and dried in the shade.

Brilliant Chinese Fire.—Four parts of charcoal, five of pounded cast iron, eight of pulverized gunpowder, six of saltpetre, six of sulphur; or three parts of pounded cast iron, eight of pulverized gunpowder, two of saltpetre, and one of sulphur; all rammed into paper-cases or other cases.

Jasmine Flowers.—This beautiful fire is generally seen in the vertical fire-wheels, &c. When the composition is well made, the sparks drop down somewhat like burning flowers of the jasmine. Its excellence depends chiefly on the use, in the composition, of bright filings or raspings from the steel-springs of clocks or watches, carefully deprived of all the finer dust that may be amongst them. The minute shavings of steel, procured from turners in metal, may also be used. Compositions for this kind of fire, six parts of steel-filings or shavings, sixteen of pulverized gunpowder, one of saltpetre, one of sulphur; or five parts of same filings, &c., sixteen of pulverized gunpowder, one of saltpetre, one of sulphur; or four parts of filings, twenty of pulverized gunpowder, one of saltpetre, one of sulphur, and four of zinc-filings or raspings, or pounded zinc rendered pulverizable by being heated to about 205 of the centigrade scale. The compositions for the Chinese fire and the jasmine flowers are to be mixed up in the same manner. The sulphur, the pounded cast iron, or the steel-filings, are mixed with the addition of a little pure alcohol, and then the other ingredients are added. It must be observed, that the size of the particles of pounded cast iron or of steel-filings should be proportioned to the size of the cases that are to be filled with the composition; the smallest filings, &c. being used for the smallest cases.

Benyal Lights.—The common ones are made of one part of antimony, five of saltpetre, and two of sulphur; the sparkling ones, of one part of antimony, two of fulminating composition (of fulminating mercury and gunpowder), four of saltpetre, and four of sulphur; or one, two, five, two parts of the same ingredients in their order; or one, two, six, one parts of the same in their order. Vases are filled with these compositions, a light gunpowder dust sprinkled over the top, and the whole closed up by a piece of paper pierced with some holes from which pieces of quick-match project. These lights may be made of any size. They sometimes weigh upwards of 200 pounds.

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[1] See the articles Gunnery, Gunpowder, Projectiles, War.

Pyro-technny.

It is necessary to warn the reader that fulminating mercury requires great caution in handling it; and, as it is so apt to explode, it had better be left out of the composition for these lights, or any other fire-works. Indeed the pyrotechnist has need to exercise the greatest possible caution in all his operations. For instance, it may, in ignorance, be imagined that no harm can happen from pounding gunpowder in a mortar along with iron or steel-filings, &c. and yet the most serious accidents may result from manipulations of this kind incautiously conducted.

One of the most formidable pyrotechnical inventions is the Congreve rocket. We have conversed with some officers who served in the war against the Burmese, and they described the effect of these rockets as appaling, not only to the Burmese, but even to the stout-hearted Britons who fired them off.

Without entering into any very minute description of the process of making such popular fire-works as the common sky-rocket, the Roman candle, &c. we shall content ourselves with a brief account of the general construction of these two. The common sky-rocket consists of a strong paper or thin pasteboard case, the lower end of which, where the cotton quick-match is inserted, is drawn so close by means of a cord as to leave only a circular opening of about one third of the interior diameter of the case. This is technically called *choking* the case. The case, when dried after pasting, is placed in a hollow cylinder of wood, into which it fits. This mould is furnished with a moveable bottom having a central nipple and a tapering spike of iron, which last, entering the aperture at the lower end of the case, rises within it nearly to the top. The space left round this spike is filled gradually, and by repeated blows from a mallet upon a hollow rammer, with a composition of pulverized gunpowder, saltpetre, and charcoal, or of sixteen parts of saltpetre, twelve of elm charcoal, and four of purified flour of sulphur. The rammer, which fits the inner diameter of the case, and to which the mallet is applied, has in its centre a deep hollow adapted to the iron spike before mentioned. The composition which forms the charge of the case must be put in by small quantities at a time, and driven down compactly by regulated blows of the mallet upon the rammer. The filling of the case in this manner requires skill and experience, because if the charge is not uniformly compacted in the case, the rocket will not rise evenly and regularly. When the charge has been driven a little higher than the top of the spike, a round piece of doubled paper is put in; and upon this one half of the inner paper of the remainder of the case is folded down and rammed firmly, so as to close the case. This plug is then pierced with a few holes, and above it are placed, along with some of the composition, or with some gunpowder, the stars, sparks, &c. that are intended to appear when the rocket has reached its highest ascent. The top of the case is then covered in, and fitted with a paper cone. In signal-rockets, that are intended to end with a report without stars, &c. the round piece of double paper before mentioned is pierced with a hole in the centre, and a little gunpowder is pressed firmly in above it, but without crushing the grains. The top of the case is then choked *close*, and the paper cone fitted on. In some other rockets that contain what are called *decorations*, that is, stars, sparks, serpents, crackers, &c., these are placed with meal-powder in a wider cylindrical case, which is fitted to the top of the case containing the charge. These rockets are also terminated by a conical cap. We may remark, that in our common rockets the conical cap is not sufficiently stiff to maintain its form invariably, and so to aid in the regular ascent of the rocket. The balance-stick has next to be fastened to the rocket. The length, thickness, and weight of this stick, require calculation to suit it to the dimensions and weight of the case. On the Continent, rockets have been made to ascend without sticks by means of a triangle of pasteboard passing round the case, or by means of three pasteboard wings glued to the case. Each of these wings forms an isosceles triangle, in height six interior diameters of the rocket-case, and a little more than two of these diameters at the base. Each of these wings must be glued on quite parallel to the axis of the case, otherwise the flight of the rocket will be irregular. A short stick with similar wings has also been employed for rocket-cases. It is stated that all these winged rockets rose beautifully, even in a violent wind and bad weather; but some allowance must surely be made for the lateral action upon them of a strong wind.

Pyrotics || Pyrrho.

The Roman candle consists of a strong case of paper or of thin pasteboard, which is completely closed at the lower end. It is generally charged with the same composition as sky-rocket cases, alternating with gunpowder and stars, as follows: First a small quantity of composition is placed at the bottom of the case, and rammed down compactly by a rammer and mallet; next a small quantity of gunpowder, and above that a star without any ramming, but a gentle push to secure the contact of the star with the gunpowder; then a quantity of the composition, which is rammed down as before; next a little more gunpowder and a star, and then more composition rammed down; and so on till the case is filled. The case is then closed by a piece of paper-match pasted round the outside, and twisted to a point at the top. The charges of Roman candles might be diversified by variously-coloured fires and stars, &c.

The reader may consult the works of which the titles are subjoined. *Essai sur les Feux d'Artifice pour le Spectacle et pour la Guerre*, Paris, 1750; *Manuel de l'Artificier*, Paris, 1757; *L'Art de faire à peu de frais les Feux d'Artifice*, Paris, 1828; *Manuel de l'Artificier*, par A. D. Vergnaud, Paris, 1828. (G. F. G.)

PYROTICS, in *Medicine*, caustics or remedies either actually or potentially hot, and which accordingly will burn the flesh, and raise an eschar.

PYRRHICA, in *Antiquity*, a kind of exercise on horseback, or a feigned combat, for the exercise of the cavalry. It was so called from its inventor Pyrrhichus or Pyrrhus of Cydonia, who first taught the Cretans to march in measure and cadence to battle, and to observe the Pyrrhic pace. Others derive the name from Pyrrhus the son of Achilles, who instituted this exercise at the obsequies of his father; but Aristotle says that it was Achilles himself who invented it. The Romans called it *ludus Trojanus*, the Trojan games; and Aulus Gellius, *decursus*. It is doubtless this exercise which we see represented on medals by two cavaliers in front running with lances, and the word *decursio* on the exergue.

PYRRHICHIUS, in Greek and Latin poetry, a foot consisting of two syllables, both short, as *Deus*. Amongst the ancients this foot was also called *periambus*, and by some *hegemona*.

PYRRHO, the founder of a school of philosophy, was the son of Pleistarchus, a native of Elis, and flourished B. C. 336, in the time of Philip the Great. He was originally a painter, but subsequently devoted himself to the study of philosophy, having been the pupil of Anaxarchus, whom he attended to India. There he became acquainted with the magi of Persia and the gymnosophists of India. On his return to Greece he acquired great renown, and was presented by the Athenians with the freedom of their city. He lived to the age of ninety. Pyrrho was the chief advocate of the sceptical school of philosophy; and from him all those who adhered to such doctrines were called Pyrrhonists. He denied that it could be proved that there was any thing in itself just or unjust, honourable or dishonourable. He considered every action and event as indifferent, and carried this idea so far as to assert that he saw

Pyrrhus || Pythagoras.

no difference between life and death. It is said that he showed no fear of death when the vessel in which he was sailing was threatened with shipwreck, and pointed to a pig, which was feeding in the utmost unconcern, remarking, that such ought to be the security of the wise man. The principle of his philosophy was, that there existed no motive for belief to which one cannot oppose a doubt of equal weight. Thus he affirmed nothing, and denied nothing. Amongst his disciples were Timon of Phlius, and Nausiphanes, who taught Epicurus. The life of Pyrrho has been written by Sextus Empiricus, and by Diogenes Laertius.

PYRRHUS, the name of two kings of Epirus. See EPIRUS.

PYTHAGORAS, a celebrated philosopher of antiquity, but one respecting the time and place of whose birth the learned are much divided. Eratosthenes asserts, that in the 48th Olympiad, about 588 years before Christ, when still very young, he was a victor at the Olympic games. Hence Dr Bentley[1] determines the date of his birth to be the fourth year of the 43d Olympiad; whilst Lloyd,[2] who denies that the Olympic victor was the same person with the philosopher, places it about the third year of the 48th Olympiad. Mr Dodwell[3] differs from both, and wishes to fix the birth of Pythagoras in the fourth year of the 52d Olympiad. Of the arguments of these learned writers, Le Clerc has given a summary in the *Bibliothèque Choisie* (tom. x. p. 81, *et seq.*); and from a review of the whole, it would appear that he was not born earlier than the fourth year of the 43d Olympiad, or later than the fourth year of the 52d; but in what particular year of that period his birth took place, cannot with any degree of certainty be ascertained. It is generally believed that he was born in the island of Samos, and that he flourished about five hundred years before Christ, in the time of Tarquin, the last king of Rome.[4] His father, Mnesarchus, who is supposed by some to have been a lapidary, and by others a merchant of Tyre, appears to have been a man of some distinction, and to have bestowed upon his son the best education.

Jamblicus[5] relates a number of wonderful stories respecting the descent of Pythagoras from Jupiter, as well as in regard to his birth and early life; and represents him even in his youth as a prodigy of wisdom and manly seriousness. But most of these idle tales confute themselves, and prove nothing but the credulity, carelessness, and prejudice of their author. Of his childhood and early education we know nothing, except that he was first instructed in his own country by Creophilus, and afterwards in Scyrus by Pherecydes. According to the custom of the times, he was made acquainted with poetry and music; eloquence and astronomy became his private studies; and in gymnastic exercises he often bore the palm for strength and dexterity. He first distinguished himself in Greece at the Olympic games, where, besides gaining the prize, he is said to have excited the highest admiration by the elegance and dignity of his person, and the brilliancy of his understanding.

Soon after his public appearance at these games, Pythagoras commenced his travels in quest of knowledge. He first visited Egypt, where, through the interest of Polycrates, tyrant of Samos, he obtained the patronage of Amasis king of Egypt, by whose influence, combined with his own assiduity, patience, and perseverance, he at length won the confidence of the priests, from whom he learned their sacred mysteries, theology, and the whole system of symbolical learning. In Egypt, too, he became acquainted with geometry and the true solar system; and, before he left that country, he had made himself master of all the learning for which it was so famed amongs the nations of antiquity. He afterwards visited Persia and Chaldæa, where from the Magi he learned divination, the art of interpreting dreams, and the science of astronomy. He is likewise said to have travelled into India, conversed with the Gymnosophists, and acquired from them a knowledge of the philosophy and literature of the East; and such was his ardour in the pursuit of science, that, according to Cicero,[6] he crossed many seas, and travelled on foot through many barbarous nations, in prosecution of his researches.

Pythagoras.

After Pythagoras had spent many years in gathering information on every subject, especially respecting the nature of the gods, the rites of religion, and the immortality of the human soul, he returned to his native island, and attempted to render his knowledge useful by there instituting a school for the instruction of his countrymen. Failing of success in this laudable undertaking, he repaired to Delos, where he pretended to receive moral dogmas from the priestess of Apollo. He then visited Crete, where he was initiated into the most sacred mysteries of Greece. He likewise repaired to Sparta and Elis, and again assisted at the Olympic games, where in the public assembly he was saluted with the title of *sophist* or wise man, which he declined for one more humble, namely, that of *philosopher*, or lover of wisdom. Having returned to Samos enriched with mythological learning and esoteric rites, he again instituted a school in that island. His mysterious symbols and oracular precepts rendered this attempt more successful than the former had been; but meeting with some opposition, or being detected in some pious frauds, he suddenly left Samos, and, retiring to Magna Græcia, settled at Crotona.

Here Pythagoras founded the Italic sect, nor was it long ere his mental and personal accomplishments, the fame of his distant travels, and his Olympic crown, procured him numerous pupils. His bold and manly eloquence and his graceful delivery attracted the most dissolute, and produced a remarkable change in the morals of the people of Crotona. His influence was increased by the regularity of his own example, and its conformity to his precepts. He punctually attended the temples of the gods, and paid his devotions at an early hour; he lived upon the purest and most innocent food, clothed himself like the priests of Egypt, and, by his continual purifications and regular offerings, appeared to be superior in sanctity to the rest of mankind. He endeavoured to assuage the passions of his scholars by means of verses and numbers, and made a practice of composing his own mind every morning, by playing on the harp, and singing along with it the pæans of Thales. To avoid the temptations of ease and the seductions of idleness, bodily exercises also formed a considerable part of his scheme of discipline.

At Crotona he had a public school for the general benefit of the people, in which he taught them their duty, praising virtue, condemning vice, and particularly instructing them in the duties of social life. Besides this, he had a college in his own house, which he denominated κοινοβιον, in which there were two classes of students; the ἐξωτερικοι, who were also called *auscultantes*, and the ἐσωτερικοι. The former of these were neophytes, and were kept under a long probation. A silence of five years was imposed upon them, which Apuleius thinks was intended to teach them modesty and attention; but Clemens Alexandrinus is of opinion that it was for the purpose of abstracting their minds from sensible objects, and inuring them to the pure contemplation of the Deity. The latter class of scholars were called *genuini*, *perfecti*, *mathematici*, and, by way of eminence, Pythagoreans. They alone were admitted to the knowledge of the arcana of the Pythagorean discipline, and were taught the use of ciphers and hieroglyphical writings.

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[1] Dissertation on the Epistles of Phalaris. [2] Chron. of Pythagoras. [3] Two Dissertations on the age of Phalereus and Pythagoras.
[4] *Quæst. Tusc.* lib. iv. cap. 1. [5] *Vit. Pythag.* 6, n. [6] *De Finibus*, lib. iv. sect. 29.

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Clemens observes, that these orders corresponded very exactly to those amongst the Hebrews. For in the schools of the prophets there were two classes; the sons of the prophets, who were the scholars, and the doctors or masters, who were also called *perfecti*, and, amongst the Levites, the novices or tyros, who had their quinquennial exercises, by way of preparation. Lastly, even amongst the proselytes there were two orders; *exoterisci*, or proselytes of the gate, and *intrinseci* or *perfecti*, proselytes of the covenant. It is highly probable, he adds, that Pythagoras himself had been a proselyte of the gate, if not of the covenant. Gale endeavours to prove that Pythagoras borrowed his philosophy from the Jews; and with this view he produces the authorities of many fathers and ancient authors, and even points out traces of Moses in several parts of Pythagoras's doctrine. But the learned author was, we believe, misled by the Christian Platonists.

The authority of Pythagoras amongst his pupils was so great that it was even deemed a crime to dispute his word; and their arguments were considered as infallibly convincing, if they could enforce them by adding that "the master said so," an expression which afterwards became proverbial, *jurare in verba magistri*. This influence over his school was soon extended to the world, and even his pupils themselves divided with their master the applause and approbation of the people; whilst the rulers and the legislators of all the principal towns of Greece, and Sicily, and Italy, boasted of being the disciples of Pythagoras. To give more weight to his exhortations, as some writers mention, Pythagoras retired into a subterranean cave, where his mother sent him intelligence of everything which happened during his absence. After a certain number of months he again re-appeared on the earth with a grim and ghastly countenance, and declared in the assembly of the people that he was just returned from the shades. From similar exaggerations, it has been asserted that he appeared at the Olympic games with a golden thigh; that he could write whatever he pleased in letters of blood on a looking-glass; and that by setting it opposite to the moon, when full, all the characters which were on the glass became legible on the moon's disc. They also relate, that by some magical words he tamed a bear, stopped the flight of an eagle, and appeared on the same day and at the same instant of time in the cities of Crotona and Metapontum.

At length his singular doctrines, and perhaps his strenuously asserting the rights of the people against their tyrannical governors, excited a spirit of jealousy, and raised against him a powerful party, which soon became so outrageous as to oblige him to fly for his life. His friends withdrew to Rhegium; and he himself, after being refused protection by the Locrians, fled to Metapontum, where he was obliged to take refuge in the temple of the Muses, and where it is said he died of hunger, about 497 years before Christ. Respecting the time, place, and manner of his death, however, there are various opinions, and many think it uncertain when, where, or in what manner he ended his days. After his death his followers paid him the same respect they would have done to the immortal gods; they erected statues in his honour, converted his house at Crotona into a temple to Ceres, appealed to him as a deity, and even swore by his name.

Pythagoras married Theano of Crotona, or, according to others, of Crete, by whom he had two sons, Telauges and Mnesarchus, who, after his death, took care of his school. He is also said to have had a daughter called Damo.

Whether he left any writings behind him is disputed. It seems probable, however, that he left none, and that such as went under his name were written by some of his followers. The *golden verses* which Hierocles has illustrated with a commentary, have been ascribed to Epicharmus or Empedocles, and contain a brief summary of his popular doctrines. From this circumstance, and from the mysterious secrecy with which he taught, our information concerning his doctrine and philosophy is very uncertain, and cannot always be depended upon.

The main purpose of philosophy, according to the system of Pythagoras, is to free the mind from encumbrances, and to raise it to the contemplation of immutable truth and the knowledge of divine and spiritual objects. To bring the mind to this state of perfection is a work of some difficulty, and requires a variety of intermediate steps. Mathematical science was with him the first step to wisdom, because it inures the mind to contemplation, and takes a middle course between corporeal and incorporeal beings. The whole science he divided into two parts, numbers and magnitude; and each of these he subdivided into two others, the former into arithmetic and music, and the latter into magnitude at rest and magnitude in motion, the one comprehending geometry and the other astronomy. Arithmetic he regarded as the noblest science, and an acquaintance with numbers as the highest good. He considered numbers as the principles of everything, and divided them into scientific and intelligible. Scientific number is the production of the powers involved in unity, and its return to the same. Number is not infinite, but it is the source of that infinite divisibility into equal parts which is the property of all bodies. Intelligible numbers are those which existed in the divine mind before all things. They are the model or archetype of the world, and the cause of the essence of beings. Of the monad, duad, triad, tetrad, and decad, various explanations have been given by different authors; but nothing certain or important is known of them. In all probability numbers were used by Pythagoras as symbolical representations of the first principles and forms of nature, especially of those eternal and immutable essences which Plato denominated ideas; and in this case the monad was the simple root from which he conceived numbers to proceed, and, as such, analogous to the simple essence of Deity, from whom, according to his system, the various properties of nature are derived.

Music followed numbers, and was held as useful in raising the mind above the dominion of the passions. Pythagoras considered it as a science to be reduced to mathematical principles and proportions, and is said to have discovered the musical chords from the circumstance of several men successively striking with hammers a piece of heated iron upon an anvil. This story Dr Burney[1] discredits, but at the same time allows, from the uniform testimony of writers ancient and modern, that he invented the *harmonical canon*, or monochord. The music of the spheres, of which every one has heard, was a most fanciful doctrine of Pythagoras. It was produced, he imagined, by the planets striking on the ether through which in their motion they passed; wherefore he considered their musical proportions as exact, and their harmony perfect.

Pythagoras, as we have already seen, learned geometry in Egypt; but, by investigating many new theorems, and by digesting its principles, he reduced it to a more regular science. A geometrical point, which he defines to be a monad, or unity with position, he says corresponds to unity in arithmetic, a line to two, a superficies to three, and a solid to four. He discovered several of the propositions of Euclid; and on discovering the 47th of the first book, he is said to have offered a hecatomb to the gods; but as he was averse to animal sacrifices, this assertion is most probably false.

Wisdom, according to Pythagoras, is conversant with

[1] History of Music, vol. i. p. 441.

Pythagoras.

those objects which are naturally immutable, eternal, and incorruptible; and its end is to assimilate the human mind to the divine, and to qualify us to join the assembly of the immortals. Active and moral philosophy prescribes rules and precepts for the conduct of life, and leads us to the practice of public and of private virtue. On these heads many of his precepts were excellent, whilst some of them were whimsical and useless. Theoretical philosophy treats of nature and its origin, and is, according to Pythagoras, the highest object of study. It included all the profound mysteries which he taught, of which but little is now known. God he considers as the universal mind, diffused throughout all things, and the self-moving principle of all things (αὐτομάτισμος τῶν παντῶν), and of whom every human soul is a portion.[1] It is very probable that he conceived of the Deity as a subtile fire, eternal, active, and intelligent; which is not inconsistent with the idea of incorporeality, as the ancients understood that term. This Deity was primarily combined with the chaotic mass of passive matter, but he had the power of separating himself, and since the separation he has remained distinct. The learned Cudworth contends that Pythagoras maintained a trinity of hypostases in the divine nature, similar to the Platonic triad. We cannot say that his arguments appear to have much force; but we think the conclusion which he wishes to establish extremely probable, as Plato certainly drew his doctrine from some of the countries which Pythagoras had visited before him.

Subordinate to the Deity there were in the Pythagorean creed three orders of intelligences; gods, demons, and heroes, of different degrees of excellence and dignity. These, together with the human soul, were considered as emanations from the Deity, the particles of subtile ether assuming a grosser clothing the farther they receded from the divine fountain. Hierocles defines a hero to be a rational mind united with a luminous body. God himself was represented under the notion of monad, and the subordinate intelligences as numbers derived from and included in unity. Man is considered as consisting of an elementary nature and a divine or rational soul. His soul, a self-moving principle, is composed of two parts; the rational, seated in the brain, and the irrational, including the passions, in the heart. In both these respects he participates with the brutes, whom the temperament of their body and other circumstances allow not to act rationally. The sensitive soul perishes; the other assumes an ethereal vehicle, and passes to the region of the dead, till sent back to the earth to inhabit some other body, brutal or human. It was unquestionably this notion which led Pythagoras and his followers to deny themselves the use of flesh, and to be so peculiarly merciful to animals of every description. Some authors, however, say that flesh and beans, the use of which he also forbade, were prohibited because he supposed them to have been produced from the same putrefied matter out of which, at the creation of the world, man was formed.

The scantiness and uncertainty of our information respecting Pythagoras renders a regular and complete account of his life and doctrines impossible. A modern author,[2] of profound erudition, pronounces him to have been unquestionably the wisest man that ever lived, if his masters the Egyptian priests must not be excepted. This is perhaps saying too much; but that he was one of the most distinguished philosophers of antiquity, or, as Cicero expresses it, *vir præstanti sapientia*, appears very evident; and his moral character has never been impeached. The mysterious air which he threw over his doctrines, and the apparent inanity of some of his symbols, have indeed subjected him to the charge of imposture; and perhaps the charge is not wholly groundless. But when we consider the age in which he lived, and the nature of the people with whom he had to deal, and who would in all probability have resisted more open innovations, even this will not appear so blameable as at first sight we are apt to think it; and it is worthy of notice, that the worst stories of this kind have come down to us in a very questionable shape, and show every appearance of being fabulous.

Pythagoreans ‖ Python.

PYTHAGOREANS, a sect of ancient philosophers, so called from their being the followers of Pythagoras.

PYTHEAS, an ancient navigator, was a native of Marseilles, and is supposed to have lived some time about the age of Alexander the Great, 330 B. C. We have no information respecting the private circumstances of his life; but we know that he explored the northern seas of Europe, though the ancient geographers appear to have placed little dependence on the statements which he made. Both Polybius and Strabo treat him with great severity, and ridicule his accounts as absurd and incredible. It would appear that he sailed through the English Channel, and, after a voyage of six days to the north, reached an island which he calls Thule, where he says that the sun never descends below the horizon for a certain period at the summer solstice. This statement would apply to Iceland, but then it seems unlikely that he could reach that island within six days. He next sailed to the north-east, and entering the Baltic, reached a river which he calls Tanaïs, and is thought to be the *Vistula*. Here he found a people who made use of amber instead of wood; and as that substance is still found in large quantities in Prussia, there is little doubt that he must have visited this part of Europe. He gave an account of his voyages in two works which he published. The one was entitled a Description of the Ocean, and contained his voyage from Gades to Thule; the other work was entitled Periplus. It is said that Pytheas was the first who suspected that the tides were influenced by the moon. (See *Eclaircissements sur la Vie et sur les Voyages de Pythéas*, by Bougainville, in the *Récueil de l'Académie des Inscriptions*, xix. 46.)

PYTHIA, the priestess of Apollo at Delphi, by whom he delivered oracles. She was so called from Pythius, a name of that god, which is said to have been given him on account of his victory over the serpent Python. The Pythia was at first required to be a young girl, but in later times a woman of about fifty years of age usually officiated as priestess. The first and most famous Pythia was Phemonöe, by whom oracles were at first delivered in hexameter verse. All the Pythias were pure virgins, and all of them delivered their oracles with great enthusiasm and violent agitations.

PYTHIAN Games, in Grecian antiquity, sports instituted near Delphos in honour of Apollo, on account of his slaying the serpent Python. These games, at their first institution, were celebrated only once in nine years; but afterwards every fifth year, from the number of the Parnassian nymphs who came to congratulate Apollo, and to make him presents on his victory. The victor was crowned with garlands.

PYTHON, in fabulous history, is the name given to a monstrous serpent, produced by the earth after Deucalion's deluge. Juno being exasperated at Latona, who was beloved by Jupiter, commanded this serpent to destroy her; but Latona flying from the pursuit of the monster, escaped to Delos, where she was delivered of Diana and Apollo, the latter of whom at length destroyed Python with his arrows, and in memory of this victory the Pythian games were instituted.

[1] Cicero *de Senectute*, sect. 21

[2] Monboddo's Ancient Metaphysics.

Q.

Q U A

Q ‖ Quadrantal.

Q, or *q*, the sixteenth letter and twelfth consonant of our alphabet, but one not to be found either in the Greek, old Latin, or Saxon alphabets; and indeed some would entirely exclude it, pretending that k ought to be used wherever this occurs. But as it is formed by the voice in a different manner, it is undoubtedly a distinct letter; for, in expressing this sound, the cheeks are contracted, and the lips, particularly the under one, are put into a canular form, for the passage of the breath.

The q is never sounded alone, but in conjunction with u, as in *quality*, *question*, *quite*, *quote*, and the like, and never ends any English word. As a numeral, Q stands for 500; and with a dash over it, thus, $\overline{Q}$, for 500,000. Used as an abbreviature, *q* signifies *quantity* or *quantum*. Thus, amongst physicians, *q. pl.* is *quantum placet*, as much as you please; and *q. s.* is *quantum sufficit*, as much as is necessary. Q.E.D. amongst mathematicians, is *quod erat demonstrandum*, which was to be demonstrated; and Q. E. F. is *quod erat faciendum*, which was to be done. Q. D. amongst grammarians is *quasi dictum*, as if it were said, or, as who should say. In the notes of the ancients, Q stands for *Quintus* or *Quintius*; Q. B. V. for *quod bene vertat*; Q. S. S. S. for *quæ supra scripta sunt*; Q. M. for *Quintus Mutius*, or *quomodo*; Quint. for *Quintilius*; and Quæs. for *quæstor*.

QUADI, a people of Germany, situated to the south-east of the mountains of Bohemia, on the banks of the Danube, and extending as far as the river Marus, running by Moravia, which country they occupied.

QUADRAGESIMA, a denomination given to Lent, from its consisting of forty days.

QUADRANGLE, in *Geometry*, the same with a quadrilateral figure, or one consisting of four sides and four angles.

QUADRANS, the quarter or fourth part of any thing, particularly the *as*, or pound.

Quadrans, in English money, the fourth part of a penny. Before the reign of Edward I. the smallest coin was a *sterling* or penny, marked with a cross, by the guidance of which a penny might be cut into halves for a halfpenny, or into quarters or four parts for farthings. But, to avoid the fraud of unequal cuttings, that king afterwards coined halfpence and farthings in distinct round pieces.

QUADRANT, in *Geometry*, the arch of a circle, containing ninety degrees, or the fourth part of the entire periphery.

Quadrant also denotes a mathematical instrument, of great use in astronomy and navigation, for taking the altitudes of the sun and stars, as also for taking angles in surveying.

This instrument is variously contrived, and furnished with different apparatus, according to the various uses it is intended for; but they all have this in common, that they consist of a quarter of a circle, the limb of which is divided into ninety degrees. Some have a plummet suspended from the centre, and are furnished with sights to look through.

The principal and most useful quadrants are the common surveying quadrant, astronomical quadrant, Adams's quadrant, Cole's quadrant, Gunter's quadrant, Hadley's quadrant, horodictical quadrant, Sutton's or Collins's quadrant, and the sinical quadrant. See Sextant.

QUADRANTAL, in *Antiquity*, the name of a vessel in use amongst the Romans for the measuring of liquids. It was at first denominated *amphora*; and afterwards quadrantal, from its form, which was square every way like a die. In capacity it contained eighty *libræ* or pounds of water, which made forty-eight *sextaries*, two *urnæ*, or eight *congii*.

Q U A

Quadrat ‖ Quadriga.

QUADRAT, a mathematical instrument, called also a *Geometrical Square*, and *Line of Shadows*. It is frequently an additional member on the face of the common quadrant, as also on those of Gunter and Sutton.

Quadrat, in printing, is a piece of metal used to fill up the void spaces between words. There are quadrats of different sizes, as m-quadrats, n-quadrats, and the like, which are respectively of the dimensions of these letters, only lower, that they may not receive the ink.

QUADRATIC Equations, in *Algebra*, those in which the unknown quantity is of two dimensions, or raised to the second power.

QUADRATRIX, in *Geometry*, a mechanical line, by means of which we can find right lines equal to the circumference of circles, or of other curves, and their several parts.

QUADRATURE, in *Geometry*, denotes the squaring, or reducing a figure to a square. Thus, the finding of a square which shall contain just as much surface or area as a circle, an ellipsis, or a triangle, is the quadrature of a circle, an ellipsis, or a triangle. The quadrature, especially amongst the ancient mathematicians, was a great postulatum. The quadrature of rectilinear figures is easily found, for it is merely the finding their areas or surfaces, that is, their squares; for the squares of equal areas are easily found by extracting the roots of the areas thus found. The quadrature of curvilinear spaces is of more difficult investigation; and in this respect extremely little was done by the ancients, except the finding the quadrature of the parabola by Archimedes. In the year 1657, Sir Paul Neil, Lord Brouncker, and Sir Christopher Wren, geometrically demonstrated the equality of some curvilinear figures to rectilinear spaces; and soon afterwards the same thing was proved both at home and abroad of other curves, and which were brought under an analytical calculus. The first specimen of this was given to the public in 1688, by Mercator, in a demonstration of Lord Brouncker's quadrature of the hyperbola, by Dr Wallis's reduction of a fraction into an infinite series by division. Sir Isaac Newton, however, had before discovered a method of attaining the quantity of all quadruple curves analytically by his fluxionary calculus. It was disputed between Sir Christopher Wren and Mr Huygens which of them had first discovered the quadrature of any determinate cycloidal space. Leibnitz afterwards found that of another space; and in 1669 Bernoulli discovered the quadrature of an infinity of cycloidal spaces, both segments and sectors.

Quadrature, in *Astronomy*, that aspect of the moon when she is ninety degrees distant from the sun; or when she is in a middle point of her orbit, between the points of conjunction and opposition, namely, in the first and third quarters.

QUADREL, in building, a kind of artificial stone, so called from its being perfectly square. The quadrels are made of a chalky earth, &c. and dried in the shade for two years. These were formerly in great request amongst the Italian architects.

QUADRIGA, in *Antiquity*, a car or chariot drawn by four horses. On the reverses of medals we frequently see the Emperor or Victory in a quadriga, holding the reins of

Quadrilateral ‖ Quadrille.

the horses; and hence these coins are amongst the curious called *nummi quadrigati* and *victoriati*.

QUADRILATERAL, in *Geometry*, a figure, the perimeter of which consists of four sides and four angles, and which is also called a *quadrangular figure*.

QUADRILLE, a little troop or company of cavaliers, pompously dressed and mounted, for the performance of carousals, jousts, tournaments, and other gallant divertisements.

QUADRILLE, a game played by four persons, with forty cards, which are the remains of a pack after the four tens, nines, and eighths are discarded. These are dealt three and three, and one round four, to the right-hand player; and the trump is made by him who plays with or without calling, by naming spades, clubs, diamonds, or hearts, and the suite named is trumps. If the person who names the trump should mistake, and say spades instead of clubs, or if he name two suites, the first named is the trump.

In this game the order of the cards, according to their natural value, is as follows. Of hearts and diamonds, *king, queen, knave, ace, deuce, three, four, five, six, seven*, in all ten; of spades and clubs, *king, queen, knave, seven, six, five, four, three, deuce*, in all nine. The reason why the ace of spades and ace of clubs are not mentioned is, because they are always trumps, in whatever suite they may be played; the ace of spades being always the first, and the ace of clubs the third trump. The cards rank according to their value, when trumps stand in the following order: Hearts and diamonds, SPADILL, or the *ace of spades*; MANILL, the *seventh* of the two *red suites*; BASTO, the *ace of clubs*; PONTO, *the ace of hearts and diamonds; king, queen, knave, deuce, three, four, five, six*; in all twelve. Spades and clubs, SPADILL, the *ace of spades*; MANILL, the *deuce of spades and clubs*; BASTO, the *ace of clubs; king, queen, knave, seven, six, five, four, three*; in all eleven. It is here to be observed, that the card which is *manill* and the second trump is always the lowest in its suite when not trumps; and that the ace of hearts or diamonds, which when trump is above the king, is below the knave when not trump.

There are three matadores, spadill, manill, and basto; the privilege of which is, that when the player has no other trumps but them, and trumps are led, he is not obliged to play them, but may play what card he thinks proper, provided, however, that the trump led is of an inferior rank; but if spadill should be led, he that has manill or basto only is obliged to play it. It is the same of manill and basto with respect to the superior matadore always forcing the inferior. Though there are properly but three matadores, nevertheless all those trumps which follow the three first without interruption are likewise called matadores; but the three first only enjoy the privilege above mentioned.

Each person is to play as he judges most convenient for his own game. He is not to encourage his friend to play; but each person ought to know what to do when it is his turn to play. The stakes consist of seven equal mils, or *contrats*, as they are sometimes called, comprising the ten counters and fishes, which are given to each player. A mil is equal to ten fish, and each fish to ten counters. The value of the fish is according to the players' agreement, as also the number of tours, which are generally fixed at ten, and marked by turning the corners of a card.

If the cards should happen not to be dealt rightly, or that there should be two cards of the same sort, as two deuces of spades, for example, there must be a new deal, provided it is discovered before the cards are all played. The cards must likewise be dealt over again in case a card is turned in dealing, as it might be of prejudice to him who should have it, and of course if there should be several cards turned. There is no penalty for dealing wrong; he who does so must only deal again.

Quadrille.

When each player has got his ten cards, he that is on the right hand of the dealer, after examining his game, and finding his hand fit to play, asks if they play; or if he has not a good hand he passes, and so the second, third, and fourth. All the four may pass; but he that has spadill, after having shown or named it, is obliged to play by calling a king. Whether the deal is played in this manner, or that one of the players has asked leave, nobody choosing to play without calling, the eldest hand must begin the play, first naming the suite and the king which he calls; he who wins the trick plays another card, and so of the rest till the game is finished. The tricks then are counted; and if the ombre, that is, he who stands the game, has, together with him who is the king called, six tricks, they have won and are paid the game, the consolation, and the matadores if they have them, and divide what is upon the game, and the beasts if there are any. But if they make only five tricks, it is a remise, and they are beasted what goes upon the game, paying to the other players the consolation and the matadores. If the tricks be equally divided between them, they are likewise beasted; and if they make only four tricks between them it is a remise; if they make less they lose codill, and in that case they pay to their adversaries what they should have received if they had won, that is, the game, the consolation, and the matadores if they have them, and are beasted what is upon the game. They who win codill divide the stakes. The beast, and everything else that is paid, is paid equally between the two losers; one half by him that calls, and the other half by him that is called, as well in case of codill as a remise; unless the ombre does not make three tricks, in which case he that is called is not only exempted from paying half the beast, but also the game, the consolation, and the matadores if there are any, which the ombre in that case pays alone; and as well in case of a codill as a remise. This is done in order to oblige players not to play games that are unreasonable. There is nevertheless one case in which, if the ombre makes only one trick, he is not beasted alone, and that is when, not having a good hand, he passes, and all the other players have passed likewise; he having spadill is obliged to play. Here it would be unjust to oblige him to make three or four tricks. In this case, therefore, he that is called pays one half of the losings; for which reason he that has spadill with a bad hand should pass, that if he is afterwards obliged to play by calling a king, which is called *forced spadill*, he may not be beasted alone. He who has once passed cannot be admitted to play; and he who has asked leave cannot refuse to play, unless any one should offer to play without calling.

He who has four kings, may call a queen to one of his kings, except that which is trump. He who wants one or more kings, may call one of those kings; but in that case he must make six tricks alone, and consequently he wins or loses alone. The king of that suite in which he plays cannot be called. No one should play out of his turn, although he is not beasted for so doing. If he who is not the eldest hand has the king called, and plays spadill, manill, or basto, or even the king called in order to show that he is the friend, having other kings that he fears the ombre should trump, he is not to be allowed to go for the vole; he is even beasted, if it appears to be done with that intent. It is not permitted to show a hand though codill may already be won, that it may be seen whether the ombre is beasted alone. If the ombre or his friend shows their cards before they have made six tricks, thinking that they have made them, and there appears a possibility of preventing their making them, the other players can oblige them to play their cards as they think proper.

A player need only name his suite when he plays without calling a king. He who plays without calling must

Quadrille.

make six tricks alone to win; for all the other players are united against him, and they are to do what they can to prevent his winning. He who plays without calling, is admitted to play in preference to him who would play with calling; however, if he that has asked leave will play without calling, he has the preference of the other who would force him. These are the two methods of play without calling that are called forced.

As he who plays without calling does not divide the winnings with any person, he consequently, when he loses, pays all by himself. If he loses by remise he is beasted, and pays each of the other players the consolation, the *sans appeller* (which is commonly, but improperly, called the *sans prendre*), and the matadores if there are any; if he loses codill he is likewise beasted, and pays to each player what he would have received from each if he had won. They who win codill divide what there is; and if there are any counters remaining, they belong to him of the three who shall have spadill or the highest trump the next deal. It is the same with regard to him who calls one of his own kings; he wins alone or loses alone as in the other case, except the sans appeller, which he does not pay if he loses, or receive if he wins, although he plays alone.

If he plays sans appeller, though he may have a sure game, he is obliged to name his suite; which if he neglects to do, and shows his cards, and says, "I play sans appeller," in that case neither of the other players can oblige him to play in what suite he pleases, although he should not have one trump in that suite.

He who has asked leave is not permitted to play sans appeller unless he is forced; in which case, as was said before, he has the preference of the other who forces him.

A player is not obliged to trump when he has none of the suite led, nor play a higher card in that suite if he has it, being at his option although he is the last player, and the trick should belong to the ombre; but he is obliged to play in the suite led if he can, otherwise he renounces. If he separates a card from his game, and shows it, he is obliged to play it, if by not doing it the game may be prejudiced, or if he can give any intelligence to his friend, but especially if it should be a matadore. He who plays sans appeller, or by calling himself, is not subject to this law. He may turn the tricks made by the other players, and count what has been played, as often as it is his turn to play, but not otherwise. If, instead of turning a player's tricks, he turns and sees his game, or shows it to the other players, he is beasted, together with him whose cards he turned; and each of them must pay one half of the beast.

If any one renounces, he is beasted as often as he has renounced and it is detected; but a renounce is not made till the trick is turned. If the renounce is discovered before the deal is finished, and has been detrimental to the game, the cards must be taken up again, and the game replayed from that trick where the renounce was made; but if the cards are all played, the beast is still made, and the cards must not be replayed; except there should be several renounces in the same deal: then they are to be played again, unless the cards should be mixed. If several beasts are made in the same deal, they all go together, unless it is otherwise agreed at the beginning of the party; and when there are several beasts, the greatest always goes first.

A great advantage accrues from being eldest hand at quadrille, which often renders it very disagreeable to the rest of the players, being obliged to pass with a good hand unless they choose to play alone; and when it happens that the eldest hand having asked leave, the second player has three matadores, several trumps in back, and all small cards, he cannot then even play alone; and having no chance of being called, he must pass with this good hand: on account of which, this method has been thought expedient, to remedy this defect of the game; each player having an opportunity of availing himself of the goodness of his game, by adding to the usual method of playing the game that of the mediateur, and the favourite suite.

Quadripartition || Quadruple.

The first thing to be observed is that of drawing for places, which is done in this manner: One of the players takes four cards, a king, a queen, a knave, and an ace; each player draws one of these cards, and commonly he who comes in last draws first. The person who draws the king sits where he pleases, the queen at his right hand, the knave next the queen, and the ace on the left of the king. The king draws the favourite suite. The number of cards and persons is the same at this game as the other, and is played in the same manner.

The favourite suite is determined by drawing a card out of the pack, and is of the same suite, during the whole party, of the card so drawn.

A king is the mediateur, which is demanded of the others by one of the players, who has a hand he expects to make five tricks of; and through the assistance of this king he can play alone and make six tricks.

In return for the king received, he gives what card he thinks proper with a fish; but must give two fish if it is in the favourite suite. He who asks by calling in the favourite suite, has the preference to him who asks by calling in another; he who asks with the mediateur has the preference to him who asks by calling in the favourite suite, and by playing alone is obliged to make six tricks to win. He who asks with the mediateur in the favourite suite, has the preference to him who asks with the mediateur in any other suite, and is obliged to play alone, and to make six tricks.

If sans prendre is played in any other suite than the favourite, he who plays it has the preference to him who asks only, or with the mediateur, or even he who plays in the favourite suite with the mediateur; and the sans prendre in the favourite suite has the preference to all other players whatever.

The only difference between this method of playing the game and the other is, that when one of the players demands the mediateur he is obliged to play alone, and to make six tricks, as if he played sans prendre. In this case he should judge, from the strength of his hand, whether the aid of the king will enable him to play alone or not.

With the mediateur and without the favourite suite it is played in this manner. The game is marked and played the same as in common, except that a fish extraordinary is given to him who plays the mediateur, and to him who plays sans prendre; that is, he who wins the mediateur receives thirteen counters from each; and if he loses by remise he pays twelve to each, and thirteen if by codill. The winner of sans prendre receives seventeen counters from each; and if by remise he loses, he pays sixteen to each, and seventeen if by codill.

The vole with the mediateur receives one fish only, as at common quadrille. The beasts are also the same as the common game. The last game is generally played double, and is called *paulans;* but for those who choose to play a higher game, they may play the double colour, which is called the *Turk*, and is double of the favourite suite. There is also a higher game than this, which is paying whatever is agreed to him who happens to hold the two aces in his hand.

QUADRIPARTITION, the dividing by four, or into four equal parts. Hence comes the term *quadripartite*, the fourth part, or something divided into four.

QUADRUPEDS, in *Zoology*, those animals which have four limbs or legs proceeding from the trunk of their body.

QUADRUPLE, fourfold, or something taken four times, or multiplied by four, on which account it is the converse of quadripartition.

QUAIL. See ORNITHOLOGY.

QUAKERS.

Quakers.

Ideas commonly entertained of Quakers and Quakerism.

QUAKERS, a body of Protestant Dissenters, so named by the public at large, but styled by themselves, "The Society of Friends." This society was founded by George Fox, in the year 1647. The Friends are remarkable for differing from the community in religious doctrines, mode of worship, and social customs, more than any other body of Christians; and it may safely be asserted, that their character has been less understood, and more seriously misrepresented, than that of almost any other religious association of modern times. Mosheim, Neale, Formey, Voltaire, and Hume, have given us descriptions of the Society of Friends, of which it would be difficult to say which abounds most in ignorant mistakes or wilful distortions. Of late years a fairer estimate of these people has manifested itself in the public mind. Men of deep thinking and eminent genius have been led to examine their history and writings, and have pronounced decisions upon them very different from those of the authors just mentioned. Coleridge, in his *Biographia Literaria*, says, "One assertion I will venture to make, as suggested by my own experience, that there exist folios on the human understanding, and the nature of man, which would have a far juster claim to their high rank and celebrity, if, in the whole huge volume there could be found as much fulness of heart and intellect, as bursts forth in many a simple page of George Fox." Thomas Carlyle, in his *Sartor Resartus*, pronounces George Fox "the greatest of modern reformers;" and Charles Lamb, in the *Essays of Elia*, declares, that "Sewel's History of the Quakers is worth all other ecclesiastical history put together."

We shall now proceed to give such an account of the rise, progress, and opinions of this society, as an intimate acquaintance with it and the writings of its members enables us to furnish, and as will be found amply borne out by a careful reference to the most authentic records, and to its existing condition.

It has commonly been stated, that this society was, at its commencement, termed the *Family of Love*, or *Seekers*. But this is a mistake. The *Seekers* were a people of prior origin, and of very different notions. From their peculiar extravagance they acquired the name of *Ranters*, and seem to have been the very people that Butler had in his eye when writing his Hudibras. They held that

> Saints may do the same things by
> The spirit in sincerity
> Which other men are tempted to,
> And at the devil's instance do,
> And yet the actions be contrary,
> Just as the saints and sinners vary.[1]

Origin of the term Quaker.

The attempt to confound the Quakers with this sect, was one of the first acts employed by the enemies of Quakerism to stamp it with opprobrium. Fox occasionally fell in with them in his travels, and sharply reproved them for their errors. The Friends, for some time after they had been gathered into a distinct body, were known only by the name of "the Professors of the Light," or "Children of the Light," from "their fundamental principle, which," to use the words of William Penn, "is as the corner-stone of their fabric; and, indeed, to speak eminently and properly, their characteristic, or main distinguish ng point or principle, viz. the light of Christ within, as God's gift for man's salvation; the root of the goodly tree of doctrine that grew and branched out of it."[2] They were known by no other name till 1650, three years after the commencement of their society, when George Fox being brought before the magistrates of Derby for preaching there, and telling them to "quake at the name of the Lord," one of them, Gervase Bennett, an independent, caught up the word, and called him and his friends QUAKERS. That was the real origin of the term Quaker; "a term which," says Sewel, their historian, "so caught the public fancy, and especially that of the priests, that they sounded it gladly abroad, never after that time giving any other name to the professors of the Light, so that it soon ran all over England, and making no stand there, it quickly reached the neighbouring countries; and that English name sounding very oddly in the ears of foreigners, hath given occasion to many silly stories."[3]

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Real character of George Fox.

Perhaps to no great reformer has so little justice been done as to George Fox. Beyond the pale of his own society his character has, in fact, never been understood. By some grave and even eminent writers, he has been denounced as a silly enthusiast; by others as a blasphemer; and others, again, have denied that he was the founder of Quakerism at all. No statements can be more at variance with the truth. For three or four years after his first setting out, he was the sole preacher of the society.[4] It was he, as may be abundantly seen in the histories of the society, and the writings of his most celebrated disciples, who gave its character and constitution to this religious association. They are his opinions, his feelings, his tone of mind, which stamped it with its peculiar form and spirit. That in the fervour of his enthusiasm, and the elation of brilliant success, he ran into some fanatical extravagances, and even absurdities, is what is perhaps inseparable from the career of a sanguine advocate of great moral and social changes; and we shall soon point to some of these, in tracing his exertions for the organization of his infant society. There have, indeed, been one or two documents, a letter to Cromwell, and a letter to himself from the wife and daughters of Judge Fell, raked up out of a vast mass of manuscripts left behind him, and eagerly and repeatedly pushed before the public by his enemies, and recently again by some seceders from the Quakers themselves, in order to stamp him as a blasphemer, and a man open to the silliest adulation. It is not by such a mode, however, that the genuine character of any man is to be decided, but by a careful examination and candid judgment of his whole life and works. Did we apply so one-sided and unphilosophical a test to that of any great reformer, what should we now think of Luther, Jerome of Prague, Calvin, Knox, Wesley, or many others? If we shut our eyes to the nobler points of their characters, and opened them only to their defects; if we estimated Jerome of Prague by his recantation, Luther by his notions of combats with the devil, Calvin by the burning of Servetus, Knox by his zeal in the demolition of cathedrals, or Wesley by his belief in omens and apparitions, what an absurd verdict should we pass upon these great men! Such, however, has generally been the mode of judging of George Fox; whilst his labours, and religious and moral doctrines recorded by himself and the historians of the society, mark him as one of the most extraordinary

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[1] Penn's Rise and Progress of the Quakers, 12th edit. p. 12; Sewel's History of the Quakers, 5th edit. i. 10; Gough's History of the Quakers, i. 53. [2] Penn's Rise and Progress, p. 18. [3] Sewel's History, 5th edit. i. 43. [4] Sewel's History, i. 86.

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men of his age. We shall soon have to observe upon how many important points of morals and manners he called in question the received opinions of his time: for, whatever his sagacious mind had once embraced as truth, he had the integrity and boldness to proclaim everywhere. He advanced into the presence of princes, and proclaimed it there in the same fulness, and with the same ease and freedom, as he did amongst his own peers. Yet with this daring and determined spirit, his contemporary disciples are unanimous in attesting his gentleness and unassuming modesty amongst them. The testimony of his eminent friend, William Penn, who had seen much of society in all its gradations, is that of all those who knew him best. "He was a man that God endued with a clear and wonderful depth; a discerner of others' spirits, and very much master of his own. . . . He was of an innocent life, no busy-body, nor self-seeker; neither touchy, nor critical. . . . So meek, contented, modest, easy, steady, tender, it was a pleasure to be in his company. He exercised no authority but over evil, and that everywhere and in all; but with love, compassion, and long-suffering. A most merciful man, as ready to forgive as unapt to take or give an offence. Thousands can truly say, he was of an excellent spirit and savour amongst them, and because thereof the most excellent spirits loved him with an unfeigned and unfading love."[1]

Formation of the Society of Friends.

George Fox was born of humble parents, at Drayton, in Leicestershire. In the quaint language of Sewel, "his father was Christopher Fox, a weaver by trade, an honest man, and of such a virtuous life that his neighbours used to call him righteous Christer. His mother was Mary Lago, an upright woman, and of the stock of the martyrs."[2] George was put apprentice to "a shoemaker that dealt also in wool and in cattle;" but he became most attached to the agricultural part of his master's business. His humble origin and education have often been adverted to, as implying a stigma upon Quakerism; but it is unquestionably to this circumstance that Quakerism owes its most distinguishing features, and probably the greatest amount of good that it has done, or may yet do, in the world. As Fox grew up, pursuing his solitary occupations in the fields, his strong mind soon began to employ itself on the subject of the utmost moment to a mortal creature, the grounds of his hopes of a future existence, and the true understanding of the Scriptures. That which, at a first view, seemed to be a disadvantage to Fox, his want of learning, and his obscurity of station, have, through the native vigour of his intellect, become eminently advantageous. His mind was neither trammelled by creeds, nor directed by classical or other knowledge, nor misled by the glimmerings of school philosophy. He was thrown, by his absolute want of a higher education, on his Bible. The whole strength and earnestness of his understanding were concentrated on the inquiry into the doctrines it contained; and he seems, with a wonderful clearness and singleness of eye, to have at once comprehended the pure and simple system of the Christian faith. He embraced it heartily and for ever. No bias of selfishness, no hopes of honour or of gain, ever appeared to weigh with him for a moment; it was to Christianity for itself alone that he attached himself, and he set out to proclaim it in the face of the world, with that boldness which always distinguished him. At first his travels were principally through the midland counties, where he convinced great numbers of his principles. For four years he appears, as already stated, to have been the only preacher of those principles; and, what is singular, the second preacher of Quakerism was a woman, named Elizabeth Horton. In the fifth year of Quakerism there were, however, according to Sewel, no less than twenty-five preachers, and in the seventh year upwards of sixty. These, traversing the kingdom in all directions, excited an extraordinary commotion. But in order fully to understand the uproar which the preaching of Quakerism created, it is necessary to call to mind the features of that age, and to see what the doctrines of Fox really were.

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The age of George Fox.

George Fox made his appearance just as the struggle between the crown and the people was drawing to a close. Charles I. was already in the hands of the parliament. The monarchy had been destroyed, and the public mind was full of new schemes of liberty and legislation. Then came the struggle between the parliament and the military power. Not only the monarchy and the parliament, but the church establishment itself, fell. Men soon began to grow weary of alternate tyranny and lawlessness, both in ecclesiastical and in political matters. They were disgusted, too, with the greediness of priests of different denominations, struggling shamelessly for power and wealth. The diffusion of the Scriptures during the respective reigns of Henry VIII., Edward VI., and Elizabeth, had now made them pretty common in the hands of the people. Thousands and tens of thousands were scattered throughout the country, who were become dissatisfied with the old institutions, and anxious to ally themselves with some body, the doctrines and practice of which were more consonant to their newly-awakened ideas. But they were not merely on the watch; they were in a state of high excitement. The novelty and animating nature of the doctrines of the gospel, and perhaps still more the splendour of eastern metaphor exhibited in the prophetical writings, had thrown them everywhere into a sort of spiritual intoxication. When, therefore, George Fox made his progress through the country, his voice was like a trumpet to collect around him hosts of inquirers. Priests, notwithstanding the opposition of their order, left their pulpits; officers in the army, judges, gentlemen, mechanics, and husbandmen; all classes, indeed, flocked round him, and found in his system of a free gospel, and renouncement of the vanities of the times, that which they had hitherto sought for in vain.

Doctrines of the Friends.

The doctrines which Fox taught, and which have been received and are still held as the true faith by the Society of Friends, are principally the following.

1*st*. The great foundation and corner-stone of Quakerism, as William Penn justly terms it, is the doctrine of the Inward Light, founded on various passages of Scripture, but especially on the words of the gospel according to St. John, that "Christ is the true Light which lighteth every man that cometh into the world." They believe in the words of a document, issued by themselves, that "every man coming into the world is endued with a measure of this light, grace, and spirit of Christ, by which, as it is attended to, he is enabled to distinguish good from evil, and to correct the disorderly passions and corrupt propensities of his nature; and that without the spirit inwardly revealed, man can do nothing to the glory of God, or to effect his own salvation."

2*d*. The spirituality of Christianity is a doctrine which flows directly from this root; and hence they believe in the non-essentiality of religious ceremonies. "We think," say they, "this influence (the influence of the Spirit of Christ) especially necessary to the performance of the highest act of which the human soul is capable, even the worship of the Father of lights and spirits, in spirit and in truth; therefore we consider as obstructions to pure worship all forms which divert the attention of the mind from the secret influence of this unction from the Holy One. (1 John, ii. 20–27.)" They cannot, therefore, admit of any fixed liturgy, any stated forms of prayer, or any regular preaching. "Yet, although true worship is not confined to time and place, we think it incumbent on Christians to meet often together,

[1] Penn's Rise and Progress, pp. 53–56.

[2] Sewell's History, i. 11.

Quakers. (Heb. x. 25), in testimony of their dependence on the heavenly Father, and for a renewal of their spiritual strength; nevertheless, in the performance of worship, we dare not depend for our acceptance with him on a formal repetition of the words and experiences of others; but we believe it to be our duty to cease from the activity of the imagination, and to wait in silence to have a true sight of our condition bestowed upon us." On this ground the sole outward act of worship amongst the Friends consists in meeting together and sitting down in silence, without any singing, or stated prayers or sermon.

3*d*. From the same great fundamental tenet of the society, it directly flows, that as this influence is absolutely necessary to the performance of individual worship, it is more especially so in the exercise of the ministry. There can be no preaching unless the preacher immediately feel himself moved to speak; therefore there can be no electing of particular individuals by the church, or education of them for the office of the ministry. It implies a ministry entirely of divine ordination, and without the participation of any human authority. According to this faith, there is and can be no paid priesthood. The gospel is a free gift to be freely exercised.

4*th*. The Friends do not hold the doctrine of the Trinity according to the common acceptation of the word. They think it safest in this mysterious subject to confine themselves to the terms of Scripture; and these are the words of their confession on this subject. "We agree with other professors of the Christian name in the belief in One Eternal God, the Creator and Preserver of the universe; and in Jesus Christ his Son, the Messiah and Mediator of the New Covenant (Heb. xii. 24)."

5*th*. The belief in the entire spirituality of the gospel system has led the Friends to consider some rites received and practised by other bodies of Christians as non-essential. "There are two ceremonies in use amongst most professors of the Christian name; water baptism, and what is termed the Lord's Supper. The first of these is generally considered as the essential means of initiation into the church of Christ, and the latter of maintaining communion with Him. But as we have been convinced that nothing short of his redeeming power, inwardly revealed, can set the soul free from the thraldom of sin, by this power alone we believe salvation to be effected. We hold, that as there is one Lord and one faith (Eph. iv. 5), so his baptism is one in nature and operation; that nothing short of it can make us living members of his mystical body; and that the baptism of water, administered by his forerunner John, belonged, as the latter confessed, to an inferior and decreasing dispensation (John iii. 30). With respect to the other rite, we believe that communion between Christ and his church is not maintained by that nor by any other external performance, but only by a real participation in his divine nature (2 Pet. i. 4) through faith; that this is the supper alluded to in the Revelations (Rev. iii. 20), 'Behold I stand at the door and knock; if any man hear my voice, and open the door, I will come in to him, and sup with him, and he with me;' and that where the substance is attained, it is unnecessary to attend to the shadow, which doth not confer grace, and concerning which, opinions so different, and animosities so violent, have arisen."

6*th*. Their great doctrine of the Inward Light necessarily implies the doctrine of repentance and a new life; in the words of Penn, "Repentance from dead works to serve the living God, which comprehends three operations. *First*, a sight of sin; *secondly*, a sense and godly sorrow for sin; *thirdly*, an amendment for the time to come. This was the repentance they (the first Quakers) preached and pressed, and a natural result of the principle they turned all people unto."[1] Quakers.

7*th*. "From hence sprung another doctrine which they were led to declare. Perfection from sin, according to the Scriptures of truth, which testify it to be the end of Christ's coming, and the nature of his kingdom, and for which his Spirit was and is given, viz. to be perfect as our heavenly Father is perfect, and holy because God is holy. . . . But they never held a perfection of wisdom and glory in this life, or from natural infirmities, or death, as some have, with a weak and ill mind, imagined and insinuated against them."[2]

Such are the great and strictly religious doctrines of the Society of Friends. There are others which they hold in common with other Christians, and which need not be enumerated here; but there are others, again, constituting a great system of philosophy, of morals, and manners, which distinguished the faith of George Fox from that of his predecessors and contemporaries, and which, if permitted to operate freely throughout society, would unquestionably produce the most amazing and beneficent changes. In the gospel declarations, that "God made of one blood all the nations of the earth," and that "he is no respecter of persons," he perceived nothing less than a charter of the most perfect freedom and equality of right to the whole human race. He carried out this idea so liberally, that he extended it to the female part of the community. He declared the equality of the sexes; that there is no sex in souls, but all are one in Christ Jesus; and on this ground he gave the female Friends a participation in the civil economy of the society. He extended this doctrine to all nations and colours; one right and one law for all men, whether white or black. In the declaration of Christ, the heathen lorded it over one another, but it should not be so amongst his disciples, where he saw the law of brotherhood, and not of subjection. This law once recognised, he could no longer recognise the contrary law of bloodshed and revenge; he was bound to pronounce the anti-Christianity of war. He pronounced the anti-Christianity of all oaths, on the clear and unequivocal command of Christ, "Swear not at all."

Peculiar customs and practices.

He regarded Christianity as a heavenly dispensation, sent down to draw us from the follies and vanities of the world, and the very essence of which consisted in a renewed vitality of mind. This led him to resist, despise, and expose those assumptions of absurd titles, those demands of servile obeisance and empty flatteries by mere wealth and factitious rank, which degrade both givers and receivers, and fill the world with so much misery and heart-burnings, so much meanness and pride. On this principle he adopted the utmost simplicity of dress and manners. He resumed the original use of *thee* and *thou* to a single person, the more so as *you* was then used to a rich person, and *thou* to a poor one. He abandoned the practice of what he called "hat-homage," taking off the hat, and bowing, as marks of obeisance to superiors. He refused to address persons of rank by the titles of your Majesty, your Excellency, your Grace, &c., looking upon it as the basest flattery, where there happened to be neither majesty, excellency, nor grace. Believing in the authenticity of no ministry but such as depended alone upon the teaching of the Holy Ghost, he denied the right to tithes, church-rates, or any compulsory payments to the support of a priesthood. As he regarded the ceremony of marriage as requiring for its celebration no interference of a minister of the gospel, he refused the mode adopted at the altars of the Established Church, and introduced a simple form of marriage in the meetings of his own society. He rejected the common customs of mourning and burial, as not being in accordance with the simplicity of the Gospel. Regarding the names of the months and

[1] Penn's Rise and Progress. p. 19.

[2] *Ibid*. p. 19.

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days of the week as originating in mythological idolatry, he substituted a mere numerical nomenclature. Various practices and social indulgences, as singing, dancing, music, the frequenting of theatres and other places of public amusement, playing at games of chance for money, drinking of healths, horse-racing, and field-sports, were renounced and discouraged by him, as incurring waste of time, or inconsistent with the serious hopes and duties of Christians. These innovations were all adopted by the Society of Friends, and have become fixed rules of practice.

The first preachers among the Friends.

It is obvious that a system like this could not be promulgated without setting in array against it an innumerable host of enemies. There was scarcely a custom of society, or a profession in it, at which it did not aim a severe blow. The church, the army, the law, each felt that it was menaced with decay or change. Royalty saw, that if this doctrine succeeded, it would lop off the right arm of arbitrary power, for it could not flatter the divine right of kings. The clergy saw that it did not object to this or that dogma, this or that ceremony, like the Puritans, but it assailed, root and branch, state-religion itself. If Quakerism succeeded, where would be the soldier and the marine; where the gainful trade of litigation? It was a system which aimed a death-blow at the flatteries of the world, and the self-gratulation and self-indulgent spirit of human nature; and it was accordingly speedily saluted with one general and furious tempest of hatred and vengeance. But, before turning to the persecutions of the Quakers, we must first notice the singular zeal, and as singular enterprises, of their first ministers. It has been stated, that, in the seventh year of Quakerism, these ministers amounted to upwards of sixty. These numbers continued for some years to increase rapidly; and they were animated with a surprising spirit of proselytism. Of these, Francis Howgill, John Audland, Samuel Fisher, had been clergymen; George Bishop, Richard Hubberthorn, William Ames, officers in the army; Anthony Pearson, John Crook, justices of peace. Of the rest, Edward Burrough, Robert Farnsworth, James Nayler, William Dewsbury, John Camm, Thomas Lowe, William Caton, and James Parnel, were amongst the most eminent. William Penn and Robert Barclay, two of their most celebrated members, did not join the society till about twenty years after its formation. There were also a considerable number of women-preachers, who displayed a spirit as bold and zealous as the men.

Firmly persuaded that they were actuated by the immediate influence and revelation of the Divine Spirit, and ordained to restore the primitive form and simplicity of the Christian faith, the Quaker-preachers traversed every quarter of the united kingdom, entering the churches of the establishment, denouncing their ceremonies and doctrines, telling the people that they were come to call them off from such things, from "the beggarly elements" of outward observances and outward teachers, to the great Inward Teacher; that the ground on which these churches stood was no more holy than any other ground;[1] and that sprinkling with water, putting on of surplices, and repeating ready-made prayers, were but relics of Popery. As these clergy and churches were maintained by the nation, they conceived that they had the clearest right to call upon the nation to look into them. They did not stop here; they believed it their duty to address solemn warnings to magistrates, to parliament, to the protector or the king as it might be, on what they regarded as their duty to the public. George Fox, Edward Burrough, Samuel Fisher, George Whitehead, and others of the Friends, had repeated interviews with Cromwell, Charles II., and other monarchs; and William Penn was a regular visitor at court during the short reign of James II.[2] Many of the preachers extended their travels to France, Germany, Holland, and America. George Fox himself visited Holland, America, and the West Indies. Penn and Barclay visited Holland and Germany, and were received with the most cordial sympathy by Elizabeth, the princess of the palatinate, who entered into a religious correspondence with them.

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Their zeal and singular actions.

Their success, and perhaps the very heat and opposition of the times, so stimulated their zeal and confirmed their opinions, that they now declared that they moved in the same spirit and power as the apostles. George Fox declared them little better than impostors who did not possess and act in that power and spirit. He believed, that by the Inward Light, not only the Scriptures, but both the intellectual and physical world, were opened to him. "He knew not only a renewing of the heart, and a restoration of the mind, but the *virtues of the creatures were also opened to him;* so that he began to deliberate whether he should practise physic for the good of mankind....The three great professions in the world, physic, divinity, and law, were opened to him," &c.[3] He worked miracles, according to his own testimony and that of his friends. He cured a woman of a distracted mind, by merely telling her, in the name of the Lord, to be quiet.[4] He commanded a man at Arn-side to stretch out his withered arm, and it was restored.[5] But he believed himself not only endowed with the apostolic, but with the prophetic power. He foretold to Judge Fell, a fortnight before any body else dreamed of such a thing, the dissolution of the parliament by force.[6] He had a vision of an angel with a fiery sword, prophetic of the great fire in London.[7] Meeting Cromwell riding in Hampton-Court Park, as he drew near, "he perceived a shaft of death go forth from him." Cromwell invited him to come to the palace, but on going the next day he found him already on his death-bed.[8] He exercised the same gift on many other occasions, foretelling judgments on his persecutors. His coadjutors laid claim to the same revelations. They were zealous to the last to address warnings to magistrates and to governments; as Francis Howgill to Cromwell;[9] Samuel Fisher to the parliament;[10] Edward Burrough to Cromwell and his council, &c.[11] They foretold events. Thomas Aldam foretold the fall of Cromwell;[12] George Bishop, the great plague in London;[13] Thomas Ibbitt, Humphry Smith, George Fox the younger, and Thomas Briggs, the great fire of London;[14] Edward Burrough, the death of Cromwell, his own death, and various other events.[15] They exhibited signs, like the ancient prophets. A woman went into the parliament in 1658, with a pitcher in her hand, and breaking it, told them, so should they be broken to pieces.[16] Thomas Aldam took off his cap before the Protector, and tearing it to pieces, said, "so shall the government be rent from thee and thy house."[17] In 1660, Robert Huntingdon went into the church at Brough, near Carlisle, wrapped in a white sheet, and with a halter about his neck, to show the Independents and Presbyterians that the surplice would be introduced again, and that some of them would be hanged.[18] A woman appeared in a Protestant church at Dieppe, in sackcloth and ashes.[19] Thomas Ibbitt, two days

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[1] Sewel's History, i. 79.
[2] *Ibid.* i. 273, 315–316; ii. 548, 559, 594, 613, 617.
[3] George Fox's Journal, 6th edit. i. 106; Sewel, i. 29.
[4] *Ibid.* i. 120; *Ibid.* i. 37.
[5] *Ibid.* i. 219.
[6] Sewel's History, i. 112, 113.
[7] *Ibid.* ii. 101.
[8] Sewel's History, i. 315, 316.
[9] *Ibid.* i. 139.
[10] *Ibid.* i. 226.
[11] *Ibid.* i. 210, 276.
[12] *Ibid.* i. 325.
[13] *Ibid.* i. 260.
[14] Sewel's History, ii. 175, 199, 388.
[15] *Ibid.* i. 315; ii. 50.
[16] *Ibid.* i. 312.
[17] *Ibid.* i. 313.
[18] *Ibid.* i. 436.
[19] *Ibid.* i. 191.

Quakers. before the fire of London, dismounted from his horse with his clothes hanging loosely about him, as though he had come in great haste, and went about the city denouncing judgment.[1] Solomon Eccles went into a Catholic chapel at Galloway, in Ireland, and, when the people were on their knees, appeared naked above his waist, with a chafing-dish of coals and burning brimstone on his head, and, crying "Woe to these idolatrous worshippers," declared that God had sent him to show them their portion, unless they repented. The same man went into a church in Aldermanbury in 1659, and, seating himself on the pulpit-cushion, in the face of the audience, began to sew.[2] In 1662, Daniel Baker, being in a ship becalmed opposite to Gibraltar, went ashore on Maunday Thursday, proceeded to the mass-house, and amid the people at high mass he rent his clothes, discovering sackcloth on his body; then taking his hat from his head, he threw it on the ground and stamped on it, and calling on them to repent, so passed away.[3]

Zeal of the first Quakers.

But the zeal of the first Quakers could not expend itself even in these extraordinary demonstrations; many of them set out to the very ends of the earth, with what they believed to be commissions from on high. One young woman, Mary Fisher, proceeded to Adrianople (although once stopped at Venice, and sent back by the British consul) to convert the Grand Turk, who received her in the most courteous manner.[4] Two others, Catharine Evans and Sarah Cheevers, went to Malta to reclaim the Catholic inhabitants, but did not meet with so handsome a reception as their sister had done from the Sultan. They were clapped into the prison of the Inquisition, and only liberated after a four years' imprisonment, through the interference of Lord D'Aubigny.[5] John Love, John Perrot, Samuel Fisher, and John Stubbs, went to Rome, to testify, in the presence of the pope and cardinals, against their superstitions. Love died in the Inquisition, but the others escaped.[6] George Robinson travelled to Jerusalem to denounce the trade which the friars made of the holy sepulchre, and to convert the Mahommedans, and also returned safe.[7] Others crossed to New England, where we shall have occasion to speak of them immediately. This is a portion of the Quaker history, which suggests serious ideas. All these things were done under the conviction of immediate revelation; but the result of these strange signs and journeys did not justify the singular anomaly of the actions; and, what is remarkable, they have never, at any subsequent period, found imitators in the society. In the sober judgment of this age, such things will no doubt be estimated at their true value; and, from the present practice and character of the Friends, we presume they would not differ much in opinion from their neighbours.[8]

Persecutions suffered by the Friends.

The persecutions which the Friends suffered forms another remarkable chapter in their history, and one in which they appear to great advantage. We have seen what were their doctrines, and that their promulgation was sure to plunge them into a sea of suffering. This was soon verified. Wherever they appeared, the clergy, who justly looked upon them as the most daring and determined enemies that ever appeared against them (for they everywhere declared to the people that their system was anti-Christian, and rotten to the very core), on all hands roused the civil and military powers against them. Wherever they preached they were hauled before the magistrates, fined or imprisoned; but though the persecution waxed hotter and fiercer every day, they never for a moment flinched, or remitted their activity in travelling and preaching all over the country. No persecution in modern times fell more heavily or savagely upon any people; and it must be said, to the honour of the society, that no people ever stood up more firmly for the rights of conscience and the liberty of the subject. The trials of the Friends, and especially that of John Crook in 1662,[9] and that of William Penn and William Mead in 1670,[10] at the Old Bailey, will for ever remain as noble monuments of their resistance to the arbitrary proceedings of the courts of judicature at that time, and their violent infringement of the privilege of jury. In the latter case there happened to be a noble jury, who, insensible to the most atrocious attempts made by the court to force a verdict, were shut up without "meat, drink, fire, or tobacco," for two nights and a day, and, still remaining immoveable, were conveyed with the prisoners to Newgate.

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The enemies of the Quakers were furnished with abundant means of oppression, in the various acts which had been passed since the days of Henry VIII. till then, against the Popish recusants, and otherwise, to compel conformity to the established church. There was the 27th of Henry VIII.; the 1st of Elizabeth, for twelvepence a day; the 5th of Eliz. *De Excommunicato capiendo;* the 35th of Elizabeth, for abjuring the realm, on pain of death; the 3d of James I. for præmunire, imprisonment for life, and confiscation of estate; the 13th and 14th of Charles II. for transporting Quakers; the 17th of Charles II. against non-conformists; the 22d of Charles II. against seditious conventicles. They were so surrounded with snares that there existed not a chance of escape if there were the slightest desire to punish them. If all charges against them failed on any occasion, there was the oath of allegiance and supremacy always ready to present to them; and the Quakers could not take any oath whatever. But by the last act against conventicles, passed in 1670, they were completely given up as a prey to the informers. Any five persons convicted of being present in one house, over and above the ordinary family, were to be fined five shillings for the first offence, ten for a second, twenty pounds for preaching, forty for a second offence, and twenty pounds for the building in which the meeting was held, the whole to be levied by distress; and if any one person could not pay his fine, it was to be levied on any one or more who could, the informer receiving one third of the amount. Under such temptations to low cupidity, loss of their property and imprisonment of their persons spread throughout the whole country. Cromwell and Charles II. both professed a desire to stay this persecution, but they took few measures to effect this object; on the contrary, during the whole reign of Charles, persecution raged more and more vehemently. Their sufferings lasted thirty years, and the simple matter-of-fact relation of them fills two large folio volumes of more than one thousand four hundred closely printed pages. The prisons were full of them, and these prisons were pestilential dungeons, of which we can now hardly credit the description. In them there were at one time 4200 Quakers. The prisons of London had suffocating crowds in them, and the celebrated HOLE in Newgate was the death of numbers. Ellwood, the friend of Milton, and who had the honour to suggest the composition of Paradise Regained, was in Newgate amongst these numbers, and has left us, in his Life, some curious sketches of those scenes. The majority of the first preachers of Quakerism died in prison. In 1662 twenty Friends died in the London jails; in 1664 twenty-five more; in 1665 fifty-two others, besides

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[1] Sewel's History, ii. 199.
[2] *Ibid.* ii. 241; State Trials, vi. 998.
[3] Sewel's History, i. 541.
[4] *Ibid.* i. 433.
[5] Sewel's History, i. 493.
[6] *Ibid.* i. 433.
[7] *Ibid.* i. 292.
[8] Nothing is here said of the actions of James Nayler, because they were condemned by the Friends at the time, and, after his punishment, thoroughly condemned by himself.
[9] Sewel, ii. 23; Gough, i. 518; Howell's State Trials, vi. 201.
[10] State Trials, vi. 951; Sewel, ii. 259; Gough, ii. 328.

Quakers. seven who died after liberation, in consequence of their treatment during confinement. According to Besse, the historian of their sufferings, the total number of Friends who perished in prison during this period was 369. In Bristol at one time every adult was in prison. In London in 1670 Charles issued an order, signed by the archbishop of Canterbury and thirteen others, commanding Mr Christopher Wren to pull down their meeting-houses at Ratcliffe and Horsleydown, which was done, and the materials sold. Peal meeting-house was ransacked, and stripped of doors and windows. Their other meeting-houses were nailed up; and the Friends, who met on the ruins, or in the street, were driven away by soldiers, mercilessly beaten with the butt-ends of their muskets, and some of them killed. Throughout the severe winter of 1683, these steadfast people collected in the streets to worship, in spite of all pains and penalties, and suffered incredible hardships and insults. The dead were disinterred from their graves; women and children were dragged by the hair along the streets; some were pricked with needles and bodkins, and others were sold to the sugar plantations. Meantime their property was at the mercy of constables and informers, who wrenched open their doors with sledge-hammers and screws, and carried off everything, to the very children's food, often leaving not a tool to work with, or a horse to plough the land. In many instances these fellows, where the men were in prison, carried the keys of their houses in their pockets, went in and out as they pleased, declaring that they would "eat of the best and drink of the sweetest, and these rogues of Quakers should pay for all." There was levied at one time on the Friends at Bristol, for fines, L.16,400; and, from a careful examination of the records of the society, it clearly appears that property was taken or destroyed at that period to the amount of upwards of one million sterling.

This sketch of their persecutions would not be perfect if we omitted their treatment in New England. There, the colony of Independents, whose history is so well known from the circumstance of their having fled from persecution at home, and immediately become persecutors themselves, and whose cruelties to the Indians and to one another form so gloomy a passage in history, no sooner heard that two Quaker women were arrived in the harbour, than they seized on them before they could land, put them in prison, stripped them naked, and barbarously treated them. They ordered three other Quaker women to be stripped to the waist, and flogged through eleven towns, a distance of eighty miles, in all the severity of frost and snow. They then hanged three men and one woman, before a mandate from the king could arrest their bloody course.

The extent of persecution was much diminished by William Penn opening an asylum for his friends in his new state of Pennsylvania, whither great numbers emigrated; and a final stop was put to them by James II. He permitted the Friends to substitute an affirmation instead of an oath; then came the Toleration Act of William II., recognising more fully the rights of conscience; and subsequent acts legalized their marriages, and placed them at ease amongst their fellow-citizens. They still continue their conscientious refusal to pay tithes and church-rates, and these are taken by distraint, to the average annual amount of about L.11,000.

It would give an unfair view of the Society of Friends, if, after exhibiting the vehemence of their early zeal, we did not remind the reader of the peculiar spirit and circumstances of that age. Then all the elements of political and religious unrest were in a state of chaotic turbulence, and the whole style of language and of action amongst all denominations was such as would now be pronounced violent and fanatical. The Quakers, in this respect, only partook of the spirit of the age; and to understand them more truly, we must see them in their patient steadfastness under their dreadful misusage, in which they gave far higher evidence of the influence and support of the Divine Spirit, than by all their signs and wonders. It is to their everlasting honour that they never showed the least symptom of retaliation. Though often urged, when circumstances were in their favour, to denounce their enemies, they had on all such occasions but one answer, "We leave them to the Lord." They not only went on steadily, preaching and convincing thousands, but they set about and organized a system of discipline, or church-government, distinguished in a remarkable degree for its order and decorum. In the first place, they established a standing committee in London, called "The Meeting for Sufferings," for receiving the earliest accounts of the persecutions of their friends from all parts of the kingdom, and for taking the promptest measures for their mitigation. It was in this committee that George Fox was to be constantly found to the latest day of his life, whenever in London, anxiously engaged in endeavouring to alleviate the sufferings of the society. The system of discipline then organized, and which continues, in the main, as it was left by the first Quakers, we have now to describe. Quakers.

Discipline of the society.

Wherever the Friends have a meeting-house, they hold, once a month, after the meeting for worship is over, a meeting for discipline; or, in other words, for all the civil and ecclesiastical affairs of the body. Though they do not pay their ministers, they deem it right to defray their expenses when they travel in the ministry. They hold it a Christian duty to support their own poor, and to educate their children. For these purposes they raise the necessary funds by voluntary contribution at these meetings, which are called Preparative Meetings, that is, meetings preparatory to the monthly meetings, which include several preparative meetings. Each preparative meeting appoints representatives to attend the monthly meeting.

The monthly meeting receives the funds for the poor, and appropriates to each meeting what is necessary. It also receives the funds for the public schools, and for what is called "the National Stock," that is, a fund placed at the disposal of the society at large for general charges; and hands them in by its representatives to the quarterly meeting. In these monthly meetings is chiefly vested the real property of the society, as its meeting-houses, lands, &c. They judge of the fitness of persons applying for membership; excite to due attention to religious and moral duties; and deal with disorderly members. They grant certificates of membership and conduct to those removing into other monthly meetings, without which they could not be received as members. They appoint two or more persons in each particular meeting, called overseers, to watch over the general conduct of the members, maintain the decorum of the meeting, and see the discipline enforced. They appoint also two or more persons, of high religious standing, as elders, to watch over the ministry, to judge of the fitness of such as offer themselves as preachers, and to sympathise with those already acknowledged. It is contrary to the rules of the society for any of its members to go to law with each other; all differences are to be settled by arbitration; and it is the duty of the monthly meetings to deal with such as violate this rule. Parties wishing to marry appear at these meetings and declare their intention; persons are appointed to inquire whether the parties are free from other engagements, and whether they have the consent of parents or guardians. These inquiries being answered in the affirmative, and the parties signifying to the following monthly meeting their continuance in the same mind, are permitted by it to proceed.

Several of these monthly meetings compose a quarterly meeting. A quarterly meeting, indeed, generally embraces one or two counties. At the quarterly meetings are produced, from the monthly meetings, written answers to cer-

Quakers. tain standing queries respecting the conduct of the members, and the meetings' care over them. These accounts are digested into one, and sent on by representatives to the yearly meeting. The money contributions for the national stock, &c. are not forwarded by the representatives from the quarterly meetings to the yearly meeting directly, but by appointed correspondents in each quarterly meeting to the Meeting for Sufferings, which is the fiscal and executive organ of the yearly meeting. Ministers wishing to travel in the ministry in Great Britain, must obtain a certificate from their own monthly meeting; and if they extend their views to Ireland, they must take one from the quarterly meeting. The quarterly meetings assist their monthly meetings in difficult cases, and hear any appeals from their judgment.

From the quarterly meetings in spring, representatives are sent to the yearly meeting in London; thus the affairs of the society coming into operation in every meeting in the kingdom, gradually concentrating themselves into one focus, concerns of a local nature being dropped in their own proper sphere, and the monthly or quarterly meetings, and those of a more general interest being carried on to the great annual assembly. To understand, however, the mechanism of the society, it must be explained that these meetings of discipline, monthly, quarterly, and yearly, are not restricted to the representatives only. All members may, and great numbers do, attend them; for not only has every member a right to give an opinion on all public questions, but these meetings offer points of pleasant reunion and acquaintanceship. It must, too, be understood that the women, simultaneously with the men, but in a separate apartment, hold their own monthly, quarterly, and yearly meetings of discipline, in which they watch over the interests, the moral conduct, and the religious consistency of the female portion of the community. There is also, previous to any meeting of discipline, a meeting of ministers and elders, to strengthen each others' hands. To their meeting in London, more commonly called "the Morning Meeting," is intrusted the revision of manuscripts which concern the principles of the society, and the granting of certificates to ministers wishing to travel abroad during the intervals of the yearly meeting. These ministers and elders afterwards take their places in the general meetings of discipline. The ministers are also members of the Meeting for Sufferings, which, as already stated, is the standing committee of the society.

These subordinate and preliminary meetings, then, having been held, the yearly meeting comes on in London in the month of May. There is but one yearly meeting for these united kingdoms, to which come representatives from Scotland and Ireland. But in America, where the great body of the Quakers is now to be found, there are eight yearly meetings, which correspond with the English yearly meeting, and with one another; besides five yearly meetings of what are called Liberal or Hicksite Quakers, with whom neither the English nor the other American Quakers hold any communication. The discipline in all is pretty much the same, and therefore the description of that in London may represent the rest. It elects a clerk, who officiates at once as chairman and secretary, and an assistant-clerk, to relieve him by reading long documents, &c. The meeting is held by adjournment from day to day, and generally continues about ten days. It receives epistles from Friends in Ireland, and the orthodox yearly meetings in America, and appoints committees to draw up answers. It receives and considers the answers to the standing queries on the moral and religious condition of the society, from all the quarterly meetings. Accounts are laid before it by the Meeting for Sufferings, of all the seizures for tithes, church-rates, &c. It has committees sitting on the state of the public schools, on the subject of slavery, and on other questions, in which the Friends take great interest, and on which they frequently feel bound to address the crown, petition parliament, or call upon the public for its attention. It has a committee to receive all appeals against the decision of the quarterly meetings. It alone has power to alter any of the established rules of the society, or to make new ones. It sometimes appoints committees to visit such quarterly meetings as appear in need of help; and it always addresses a general epistle to the society, which is read in every meeting in the kingdom; the women Friends issuing an epistle from their meeting, addressed to the female community exclusively.[1] Quakers.

Peculiar mode of worship. In their mode of worship the Friends differ from all other Christians. Believing all worship to depend upon the immediate operation of the Holy Spirit, and having, therefore, no paid ministers, no stated prayers, no singing even, they walk into their meeting-house, the men with their hats on, and sit down in silence. They keep on their hats because they do not believe that place to be holier than any other, or that worship is more acceptable at one time than another, but that it is enjoined on us, and is good for us, to assemble ourselves together before God. They have no separate pews, but all the men sit together on one row of benches, and all the women on another. They have no pulpit, because they have no fixed preacher; but as they may have several voluntary ones, they have a long raised gallery in front of the congregation, where the ministers sit, the men facing the men, and the women facing the women of the audience. The elders sit with them, or with the overseers, in a lower gallery, still facing the meeting. As the ministry is independent of human appointment, so is it of human choice in its distribution. There may be, and often are, half a dozen ministers or more resident, as in large towns, and there may be a succession of sermons and prayers, whilst in great numbers of other meetings there is no minister, nor a word spoken, for years together, except it be by travelling ministers, who occasionally visit, not only their meetings, but each family belonging to them.

Great change in the character of the society. Such were the early Quakers, and such are the forms of polity and worship which they have left behind them. Those who now see the Friends as they are, would scarcely believe them to be descended from so fiery and innovating a race. The old Quakers were vehement in the promulgation of their principles, and aggressive in their attacks on the principles of others. The present Friends neither assail the religious doctrines of others, nor seem anxious to diffuse their own. The virtue of the first Quakers was active, that of the present is passive to a miracle. They cling tenaciously to the outward forms of their system, and to their peculiarities of dress, speech, and renunciation of popular amusements; but the ancient fire which once lit up their body seems to have gone out. They profess to hold their great principles as sacred as their ancestors did, but they show little anxiety to make them known. Much of this remarkable change is plainly attributable to natural causes. The violence of a religious paroxysm determines the length of its duration. When persecution ceased, the Friends found themselves thrown, by their abandonment of the ordinary amusements and tastes of the world, on trade for occupation, and led home for relaxation. They became busy, domestic, and of consequence wealthy. These causes will explain much, but there is another cause which will explain more of the present circumstances of the society; their great tenet, and corner-stone of their faith, the Inward Light. Carrying this doctrine to the extent which they do, that it is the all-sufficient guide; that its guidance is to be sought

[1] For all that relates to the civil and religious economy of the society, see its statute-book, The Book of the Rules of Discipline, &c.

Quakers. and waited for; that we must put down before it our own imaginations and reason, and without its impulse we must make no religious movement, it has had this effect; it has acted as a blight upon the ministry. Those who might feel disposed to address their meetings from a simple feeling of love, and desire for the salvation of their fellows, and from a belief that every good motive must come from the source of all good, and would be blessed by Him; these, perhaps the most able members of the body, have yet shrunk from the task, because they felt that they should be restrained by the elders, as persons running in their own strength, and in their own natural reason. Those who have not been so sensitive, and have been adopted as ministers, have entered upon a process of putting down every motion and faculty of their own minds, and of waiting for a direct and palpable revelation from heaven. The consequence need not be stated. It is a fact, that since the first days of Quakerism they have had few preachers of extraordinary eloquence or originality of mind. The ministry is now confessedly low, and the sermons heard in their meetings are most frequently common-place and rambling. The experiment of an unpaid ministry in their hands has been by no means a splendid one. No spread or prevalence of their doctrines has followed, at all answerable to the ground of inspiration assumed. With the exception of two preachers who have lately paid a visit to Australia and the South Sea Islands, they have sent out no missionaries, nor contributed to the funds of those societies which did, because they were not moved to it; as if the evidence of success were not sufficient warrant. In their meetings of discipline the same principle has produced the same effects. Though all profess to live under the influence of the spiritual guide, some are supposed to live under it more habitually. These have acquired the name of Weighty Friends, that is, Friends of weight of character and consequent influence. Instead, therefore, of deciding all questions in these meetings by the ordinary mode of voting, or by a show of hands, a mode, one would have imagined, particularly consonant to their views of natural right, they have adopted the singular one of deciding by weight; that is, by the dicta of the Weighty Friends, who, for the most part, are men of weighty purses too. These Friends have only to say, "I am of this or that opinion," without assigning any reason, and this is taken as the sense of the meeting, and decides the question. Thus is the government of the society thrown into the hands of an oligarchy of the most dangerous kind; for none can be more dangerous than that of an assumed sanctity; and thus are the advantages of their otherwise popular system curiously neutralized.

The same principle has operated still further. It has damped religious inquiry and discussion. In the common affairs of life and trade, where the Friends have used their understandings, they have shown themselves shrewd and successful; in matters of religion they thought it right to renounce their natural faculties, and wait. When the young have expressed to ministers, or any of their elder Friends, their doubts or uneasiness on any religious point, they have replied, "they did not feel free to discuss such matters;" they advised them to "centre down into their own minds, to turn inward to the infallible guide." The consequence became apparent in a dearth of religious intelligence. There was not the same inquiry into and clear recognition of religious doctrines amongst them as amongst other communities of Christians; and when the spirit of research burst upon them from without, they were startled. Many felt themselves like mere children in theology, and were scattered different ways.

These divisions first showed themselves in America in 1827. They originated in objections to the doctrines of a very popular and aged minister, Elias Hicks; but at the yearly meeting in Philadelphia that year, it was found that great numbers were of his opinions, and the parties came to an open rupture. The schism soon spread to New York, and the feud raged for some years with great violence, ending eventually in the total disruption of the society in America. It is difficult to state the numbers of the society, because there has always been a reluctance to take a regular census of the body. In the year 1659, from the number of females who signed petitions to parliament, it was calculated that the number altogether in England was about 30,000. At present, from calculations made by private individuals, there does not appear to be quite 20,000; but in America they have been variously estimated at from 100,000 to 160,000, and may very safely be rated at more than 100,000. The section of the American Quakers calling themselves orthodox state the numbers who avowed the opinions of Elias Hicks at 30,000; the Hicksites themselves claim 60,000. It may, therefore, be fairly taken for granted that the body there is pretty equally rent in two. The English Quakers renounced the Hicksite Quakers, though these people protested that they held, and had always held, the doctrines of the first Friends in their integrity. Scarcely was this schism effected when the Quakers in England found themselves assailed on the opposite side by a party which had been most urgent with them to disown the Hicksites. This attack appeared in the shape of a publication called "A Beacon to the Society of Friends," warning them against the errors of Hicks, and advocating water-baptism, the taking of the Lord's Supper, and other opinions which the Quakers from the first had abandoned. The heats and contentions incident to religious disputes have, on this ground, distracted the society here; some few have withdrawn from the body, and several individuals have been dismissed for adopting ceremonies which Quakerism rejects; but the body itself has hitherto remained entire. It is not necessary here to enter into the points in dispute. It may suffice to say, that the Hicksites are charged with setting the Inward Light above the Scriptures, and the Beaconites with setting the Scriptures above the Inward Light; the Hicksites with running too far into mysticism, and the Beaconites into the "beggarly elements" of outward form. Both parties appeal to Scripture against each other, and the English Friends appeal to it against them both. The circumstance to be regretted is, that this society, which has always boasted that it "has no creed," and which says, "We require no formal subscription to any articles, either as to the condition of membership, or to qualify for the services of the church; we prefer judging of men by their fruits;" should thus rend itself to pieces about "articles of faith," and the very stuff of which "creeds" are made.

Quakers. Modern schisms among the Friends.

If, however, the Society of Friends, having an "infallible guide," has not avoided wandering different ways; if, being "a Society of Friends," they have not avoided bickerings and divisions; they have the honour of being amongst the noblest and most unwearied philanthropists which the world has ever seen. In this character they have proudly maintained their testimonies. If George Fox was not untouched with the extravagances of his age, he outstripped that age two hundred years in his clear perception of the highest requirements of Christianity. He was amongst the first, if not the first, to call public attention to the dreadful state of our prisons; to the injustice of capital punishments for mere stealing; and to the atrocious system of confining fresh prisoners with the most thoroughly debased.[1] He declared the anti-christianity of war, oaths, and slavery. In the maintenance of all these great truths, to the recognition

Their high philanthropic character.

[1] Sewel, i. 67; Fox's Journal, i. 143.

Quality. of which the world is now but tardily coming, his followers have nobly emulated him. William Penn, by his just treatment of the Indians, and the full liberty of conscience granted in his new state of Pennsylvania, showed the noble lessons he had learned in this school. It was amongst the Friends that the great crusade against negro slavery commenced in the person of John Woolman, an American minister.[1] From that time to the present the Quakers have never ceased their efforts in that cause. They were the first in England to form an association for the abolition of the slave-trade. Thomas Clarkson, on setting out on his career, found them everywhere ready to co-operate with him, and to the last day of the struggle their purses and personal exertions were never spared. They have not been less zealous in spreading their opinions of the crime and impolicy of war; and in prison discipline, Elizabeth Pryor, a name not enough known or honoured, and her more known but not more deserving coadjutor Elizabeth Fry, have merited largely of the public. It is in this point of view, in thus early and steadily, theoretically and practically, exhibiting Christianity in its highest and most beneficent form, "peace on earth, and good-will towards men," that the Friends have conferred on society the greatest good of which men can be made the instruments, and deserve from it the most grateful esteem.

For a full account of the schism amongst the American Friends, we must refer to The Friend, and The Herald of Truth, journals published by the opposite parties; The Beacon, and Christian Enquirer; all published in America. In The Christian Reformer, a London Journal, a narrative may also be found, vols. xiii. xiv. xv. xvii. and xviii., old series. The English discussion has occasioned a host of pamphlets, but the chief facts regarding it are contained in The Beacon, by Isaac Crewdson; Truth Vindicated; The Crisis of the Quaker Controversy; Quakerism Examined, by John Wilkinson; An Examination of the Principles and Practices of the Quakers, by Elisha Bates; Luke Howard's Yorkshireman; Reports of the Proceedings in the Yearly Meetings of 1835 and 1836, in the Christian Advocate and Patriot newspapers; and defensive pamphlets by S. Tuke, Dr Hancocke, and others.

The history and doctrines of the early Friends will be found in George Fox's Journal; Barclay's Apology for the True Christian Divinity; The Histories of the Society, by Sewel and Gough; The History of the Sufferings of the Quakers, by Besse; The History of the Friends in Ireland, by Rutty; Ellwood's Life, written by himself; and the works of William Penn, Richard Claridge, and others. (B. E.)

The word *quality* cannot be explained. It is treated by Aristotle as a general conception.

QUALITY is a word which, as used in philosophical disquisitions, cannot be explained by any periphrasis. That which is expressed by it must be brought into the immediate view of the senses or intellect, and the name properly applied, or he who is a stranger to the word will never be made to comprehend its meaning. Aristotle, who treated it as a general conception, second in order amongst the ten predicaments or categories, gives several characters of it; but though they are all in some respects just, no man could from them, without other assistance, learn what quality is.

When a man comprehends, by means of his senses and intellect, what it is that the word *quality* denotes, he will indeed perceive that the first of these characters is applicable to some qualities and not to others; that the second is more applicable to quantity than to quality; and that it is only the third which can with propriety be considered as the general characteristic of this predicament. Thus, when we have learned by our sense of sight that whiteness is a quality of snow, and blackness of coal; and, by means of observation and reflection, that wisdom is a quality of one man, and folly of another; we must admit that the sensible quality of the snow is contrary to that of the coal, and that the intellectual quality of wisdom is contrary to that of folly. There is, however, no contrariety between wisdom and whiteness or blackness, nor between hardness or softness and any particular colour; for sensible and intellectual qualities can never be compared, and it is not easy, if indeed it be possible, to make a comparison between qualities perceptible only by different senses. Nay, amongst qualities perceptible by the same sense, we often meet with a difference where there is no contrariety; for though the figure of a cube is different from that of a sphere, and the figure of a square from that of a circle, the sphere is not contrary to the cube, nor the circle to the square.

His second characteristic of this genus is still less proper than the first. It is indeed true that some qualities admit of intension and remission; for snow is whiter than paper, and one woman is handsomer than another; but of the species of quality called figure we cannot predicate either more or less. A crown-piece may have as much of the circular quality in it as the plane of the equator, and a musket-bullet as much of the spherical quality as the orb of the sun. It is indeed a property of all quantity to admit of intension and remission; and therefore this ought to have been given as the character, not of the second, but of the third category.

That it is only from a comparison of their qualities that things are denominated like or unlike, or that one thing cannot resemble another but in some quality, is indeed a just observation. We know nothing directly except qualities sensible and intellectual (see METAPHYSICS); and as these have no resemblance to each other, we conclude that body or matter, the subject of the former, is a being unlike mind, the subject of the latter. Even of bodies themselves we can say that one is like or unlike another only by virtue of their qualities. A ball of ivory resembles a ball of snow in its figure and colour, but not in its coldness or hardness; a ball of lead may resemble a ball of snow in its figure and coldness, but not in its colour; and a cube of ivory resembles not a ball of lead either in figure, colour, or coldness. The mind of a brute resembles that of a man in its powers of sensation and perception, but does not resemble it in the powers of volition and reasoning; or at least the resemblance, in this latter instance, is very slight. All bodies resemble one another in being solid and extended, and all minds in being more or less active. Likeness or unlikeness, therefore, is the universal characteristic of the category *quality*.

Other speculations of Aristotle.

Aristotle has other speculations respecting quality which are worthy of notice. He distinguishes between qualities which are essential and those which are accidental, between qualities which are natural and those which are acquired; and he speaks of the qualities of capacity and those of completion. Extension and figure in general are qualities essential to all bodies; but a particular extension, such as an inch or an ell, and a particular figure, such as a cube or a sphere, are qualities accidental to bodies. Amongst the natural qualities of glass it is one to transmit objects of vision; but to enlarge these objects is an adventitious or acquired quality. The same quality may be natural in one substance, as attraction in the magnet; and acquired in

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[1] Journal of John Woolman; also Woolman's Considerations on the Keeping of Negroes, Philadelphia, 1754; Dublin, 1776.

Quality. another, as the same attraction in the magnetic bar. Docility may be called a quality natural to the mind of man, science an acquired one. To understand what he means by qualities of capacity and completion, it may be sufficient to observe, that every piece of iron has the qualities of a razor in capacity, because it may be converted into steel, and formed into a razor; and when it is so formed, it has, in the language of this sage, the quality of a razor in completion. Amongst the qualities of capacity and completion, the most important, and what may lead to interesting speculations, is the reasoning faculty of man. A capacity of reasoning is essential to the human mind; but the completion of this capacity or actual reasoning is not, otherwise infants and persons asleep would be excluded from the human species.

Locke's doctrine. Mr Locke has puzzled his readers with a question respecting the species of an idiot or a changeling, whom he pronounces to be something between a man and a brute.[1] It is not often that we feel ourselves inclined to regret Locke's ignorance of Aristotle's distinctions; but we cannot help thinking, that had the British philosopher attended to the Stagyrite's account of qualities in capacity and qualities in completion, this perplexing question would never have been started. It is justly observed in the Essay upon Human Understanding, that of real essences we know nothing, but that every man selects a certain number of qualities which he has always perceived united in certain beings, and, forming these into one complex conception, gives to this conception a specific name, which he applies to every being in which he finds those qualities united. This is undoubtedly the process of the mind in forming genera and species; and as the excellent author refuses the name of man to the changeling, it is obvious that the complex conception, to which he gives that name, must imply rationality, or the actual exercise of reason. But this limitation will exclude many beings from the species man, whom Mr Locke certainly considered as men and women. Not to mention infants and persons in sound sleep, how shall we class those who, after having lived thirty or forty years in the full exercise of reason, have been suddenly or by degrees deprived of it by some disorder in the brain?

> From Marlborough's eyes the streams of dotage flow,
> And Swift expires a driveller and a show.

But were the hero and the wit in those deplorable circumstances excluded from the human species, and classed between men and brutes? No, surely; they were both acknowledged to be men, because they were known to have the quality of reason in what Aristotle would have called capacity. Their dotage and drivelling originated from some disorder in their bodies, probably in the region of the brain; and Locke himself contends that no defect in body is sufficient to degrade a person from the rank of manhood. Again, lunatics have the exercise of reason, except at new and full moon. Are these unhappy beings sometimes men and sometimes a species by themselves between men and brutes?

Fallacy thereof. It appears, therefore, that not the actual exercise of reason, but reason in capacity, ought to be included in the complex conception to which we give the specific name of man, as some of the greatest men that ever lived have been during parts of their lives deprived of the power of actual reasoning. This, however, it will be said, does not remove the difficulty; for the occasional exercise of reason in lunatics, and the great exertions of it in such men as Swift and Marlborough, show that they had it in capacity at all times; whereas we have no evidence that changelings have even a capacity of reasoning at any time, since they never do a rational action, nor ever utter a sentence to the purpose. That we have no direct and positive evidence of the minds of changelings being capable of reasoning, were they supplied with proper organs, must be granted; but the probabilities of their being so are many and great. We know by experience that the actual exercise of reason may be interrupted by an occasional and accidental pressure on the brain; and therefore we cannot doubt but that if this pressure were rendered permanent by any wrong configuration of the skull given to it in the womb, or in the act of being born into the world, an infant, with a mind capable of reasoning by means of proper organs, would by this accident be rendered, throughout the whole of life, an idiot or changeling. That idiotism is caused by such accidents, and is not the quality of an inferior mind occasionally given to a human body, will at least seem probable from the following considerations.

Qualla Moorba || Quang-tong.

True doctrine. It does not appear that an animal body can live and move except whilst it is actuated by some mind. Whence, then, does the unborn infant derive its mind? It must be either immediately from God, or *ex traduce* from its parents; but if the mind of man be immaterial, it cannot be *ex traduce*. Now, as idiots are very few in number when compared with the rational part of the human species, and as God in the government of this world acts not by partial but by general laws, we must conclude that the law which he has established respecting the union of mind and matter is, that human bodies shall be animated with minds endowed with a capacity of reasoning, and that those who never exert this capacity are prevented by some such accident as we have assigned.

QUALLA MOORBA, a river and port situated on the western coast of Malacca. The river is a large one; but the entrance into it is interrupted by a heavy surge, which breaks during the south-west monsoon, and has raised a dangerous sand-bank at the mouth, which extends three miles out to sea. This river is, however, frequented by vessels, which come here on account of the tin-mines in its vicinity. It is 18 miles south of Queda.

QUANG-PING, a city of China, of the first rank, in the southern part of Petchelee, agreeably situated in a fertile and well-watered territory. Long. 114. 29. E. Lat. 36. 47. N.

QUANGSEE, a province of China, situated on the south-western frontier, and bordering on Tonquin. The country is flat in the eastern districts, which are fertile, and yield rice not only for internal consumption, but also for export to the neighbouring provinces. The remaining part of the province consists of lofty mountains covered with extensive forests. These mountains are rich in mineral wealth, containing mines of gold, silver, copper, and tin, the working of which, according to the narrow maxims of Chinese policy, was for a long time prohibited, but at last permitted under the burden of paying forty per cent. to the emperor. This, however, was with the exception of the gold-mines, which the emperor retained in his own hands. The population is estimated by Sir George Staunton at 10,000,000. The capital is Queyling or Koueiling.

QUANGTONG, a large and populous province in the south of China, bounded on the east and south by the China Sea. Along the sea-coast the country is flat and extremely fertile, producing every species of grain, of which it yields two crops in the year. The northern frontier, by which it is separated from the province of Quangsee, consists of a range of high mountains, which produce gold, copper, and iron; and also a remarkable species of timber called iron-wood, from its resemblance in its properties, namely, its colour, weight, and hardness, to that metal. A beautiful species of rosewood is also found here; and in many parts an osier, the shoots of which spread along the ground, resembling twisted cords, and are so tough and pliable that they may be

[1] Book iv. chap. 4, § 13, &c.

Quang-tong ‖ Quantity.

formed into baskets, chairs, and other pieces of furniture, and even serve for cables and ropes. Quangtong is considered as one of the most important provinces of the empire; it is well situated for trade, and, amongst numerous other ports, contains Canton, by which all the commerce between China and Europe is now carried on. The mountains on the northern frontier form the only interruption to the navigable communication between Pekin and Canton. The goods being transported across the mountains by land-carriage, are embarked upon the river of Canton, and thus conveyed by water to this great emporium. The population of this province is estimated by Sir George Staunton at 21,000,000. The governor maintains a respectable naval and military force for the suppression of piracy, as well as for overawing the rude tribes of the adjacent mountains.

QUANGTONG, a town of the Birman empire, in the province of Ava, being situated on the Irrawaddy River, twenty-five miles from the frontiers of China. The meaning of the word Quangtong, or Canton, being a port or mart, numerous towns of this name are found in the vicinity of the Chinese empire; and it is likely that the town in question was either named or built by them. It is frequented by Chinese merchants, who bring thither tea, porcelain, silks, rubies, iron, and cotton. One of the staple commodities is the brown cotton of which nankeens are made. Under a liberal commercial policy it might become a mart for European goods. Long. 96. 55. E. Lat. 24. 2. N.

QUANTITY, as explained by the great English lexicographer, is that property of any thing which may be increased or diminished. This interpretation of the word is certainly just, and for the purposes of common conversation it is sufficiently determinate; but the man of science may expect to find in a work like ours a definition of the thing signified. This, however, cannot be given. A logical definition consists of the *genus* under which the thing defined is ranked, and the *specific* difference; but quantity is ranked under no genus.

Quantity characterized by Aristotle.

In that school where such definitions were most valued, it was considered as one of the ten categories, or general conceptions, under which all the objects of human apprehension were mustered, like soldiers in an army. On this account, even Aristotle himself, who delighted in definitions, and was not easily deterred from a favourite pursuit, could not, consistently with his own rules, attempt to define quantity. He characterises it, however, in several parts of his works, and particularly in the 15th chapter of the fourth book of his Metaphysics: "Things are the *same* of which the SUBSTANCE is one; *similar*, of which the QUALITY is one; *equal*, of which the QUANTITY is one." Again, he tells us,[1] that the chief characteristic of quantity is, that it may be denominated equal and unequal.

That any man can become wiser by reading such descriptions as these, none but an idolater of Aristotle will suppose. There is, indeed, no periphrasis by which we can explain what is meant by quantity to those who have not previously formed such a notion. All that can be done by making the attempt is only to settle language, by stating exactly the cases in which we use this word in the greatest conformity to general custom; for there is a laxness or carelessness of expression in the language of most men, and our notions are frequently communicated by speech in a way by no means precise; so that it is often a great chance that the notions excited in the mind of the hearer are not exact counterparts of those in the mind of the speaker.

The understandings of men differ in nothing more remarkably than in their power of abstraction, and of rapidly forming conceptions so general and simple as not to be clogged with distinguishing circumstances, which may be different in different minds whilst uttering and hearing the same words: and it is of great consequence to a man of scientific habits, either to cultivate, if possible, this talent, or to supersede its use by studiously forming to himself notions of the most important universals in his own course of contemplation, by careful abstraction of everything extraneous. His language by this means becomes doubly instructive by its extreme precision; and he will even judge with greater certainty of notions intended to be communicated by the more slovenly language of another person. Quantity.

We cannot say that there is much ambiguity in the general use of the term quantity. But here, as in all other cases, a love of refinement, of novelty, and frequently of vanity, and the wish of appearing ingenious and original, have made men take advantage of even the small latitude with which the careless use of the word will furnish them, in order to amuse themselves and the public by giving the appearance of science to empty sounds.

The subject of mathematical reasoning.

Mathematics is undoubtedly employed in discovering and stating many relations of quantity; and it is in this category alone that any thing is contemplated by the mathematician, whether in geometry, arithmetic, or algebra. Hence mathematics have been called the science of quantity. The simplicity of the object of the mathematician's contemplation, and the unparalleled distinctiveness with which he can perceive its modifications, have enabled him to erect a body of science, eminent not only for its certainty, but also for the great length to which he can carry his reasonings without danger of error; whilst the intimate connection which this science has with the arts of life, and the important services which it has performed, have procured for it a most respectable place in the circle of the sciences. Ingenious men have availed themselves of this pre-eminence of mathematics, and have endeavoured to procure respect for their disquisitions on other subjects, by presenting them to the public as branches of mathematical science, and therefore susceptible of that accuracy and certainty which form its peculiar boast. Our moral affections, our sensations, our intellectual powers, are all susceptible of augmentation and diminution, are conceivable as greater and less when stated together, and are familiarly spoken of as admitting degrees of comparison. We are perfectly well understood when we say that one pain, heat, grief, kindness, is greater than another; and as this is the distinguishing characteristic of quantity, and as quantity is the subject of mathematical discussion, we suppose that these subjects may be treated mathematically. Accordingly, Dr Francis Hutchinson has said, amongst many things of the same kind, that the greatness of a favour is in the direct compound ratio of the service performed and the dignity of the performer, and in the inverse ratio of the merit and rank of the receiver; that the value of a character is in the compound ratio of the talents and virtue of the possessor; and he has delivered a number of formal propositions on the most interesting questions in morals, couched in this mathematical language, and even expressed by algebraic formulæ. But this is merely play on terms, and conveys no instruction. We understand the words; they contain no absurdity; and, in as far as they have a sense, we believe the propositions to be true. But they give no greater precision to our sentiments than the more usual expressions would do. If we attend closely to the meaning of any one of such propositions, we shall find that it only expresses some vague and indistinct notions of degrees of those emotions, sentiments, or qualities, which would be just as well conceived by means of the expressions of ordinary language; and that it is only by a sort of analogy or resemblance that this mathematical language conveys any notions whatever of the subjects.

[1] *Præd.* p. 34, edit. Sylb.

Quantity.

The mathematician contemplates only measureable quantities.

The object of contemplation to the mathematician is not whatever is susceptible of greater and less, but what is measurable; and geometry is not the science of magnitude, in its most abstracted and general acceptation, but of magnitude which can be measured. It is, indeed, the Science of Measure, and whatever is treated in the way of mensuration is treated mathematically. Now, in the discourse of ordinary life and of ordinary men, many things are called quantities which we cannot or do not measure. This is the case in the instances already given of the affections of the mind, pleasure, pain, beauty, wisdom, honour, and the like. We do not say that they are incapable of measure; but we have not yet been able to measure them, nor do we think of measuring them when we speak rationally and usefully about them. We therefore do not consider them mathematically; nor can we introduce mathematical precision into our discussions of these subjects until we can, and actually do, measure them. Persons who are precise in their expression will even avoid such phrases on these subjects as suppose, or strictly express, such measurement. We should be much embarrassed how to answer the question, How much pain does the toothach give you just now; and how much is it easier since yesterday? Yet the answer, if we had a measure of pain, would be as easy as to the question, How many guineas did you win at cards? or how much land have you bought? Nay, although we say familiarly, "I know well how much such a misfortune would affect you," and are understood when we say it; it would be awkward language to say, "I know well the quantity of your grief." It is in vain, therefore, to expect mathematical precision in our discourse or conceptions of quantities in the most abstracted sense. Such precision is confined to quantity which may be and is measured.[1] It is only trifling with the imagination when we employ mathematical language upon subjects which have not this property. It will therefore be of some service in science to discriminate quantities in this view; to point out what are susceptible of measure, and what are not.

Measuring explained.

What is measuring? It is one of these two things: It is either finding out some known magnitude of the thing measured, which we can demonstrate to be equal to it; or it is finding a known magnitude of it, which being taken so many times, shall be equal to it. The geometer measures the contents of a parabolic space when he exhibits a parallelogram of known dimensions, and demonstrates that this parallelogram is equal to the parabolic space. In like manner, he measures the solid contents of an infinitely extended hyperbolic spindle, when he exhibits a cone of known dimensions, and demonstrates that three of these cones are equal to the spindle.

In this process it will be found that he actually subdivides the quantity to be measured into parts of which it consists, and states these parts as actually making up the quantity, specifying each, and assigning its boundaries. He goes on with it, piece by piece, demonstrating the respective equalities as he goes along, till he has exhausted the figure, or considered all its parts. When he measures by means of a submultiple, as when he shows the surface of a sphere to be equal to four of its great circles, he stops, after having demonstrated the equality of one of these circles to one part of the surface; and then he demonstrates that there are other three parts, each of which is precisely equal to the one he has minutely considered. In this part of the process he expressly assigns the whole surface into its distinct portions, of which he demonstrates the equality.

Quantity.

But there is another kind of geometrical measurement, which proceeds on a very different principle. The geometer conceives a certain individual portion of his figure, whether line, angle, surface, or solid, as known in respect to its dimensions. He conceives this to be lifted from its place, and again laid down on the adjoining part of the figure, and that it is equal to the part which it now covers; and therefore that this part, together with the first, is double of the first. He lifts it again, and lays it down on the next adjoining part, and affirms that this, added to the two former, make up a quantity triple of the first. He goes on in this way, making similar inferences, till he can demonstrate that he has in this manner covered the whole figure by twenty applications, and that his moveable figure will cover no more; and he affirms that the figure is twenty times the part employed.

Euclid's fourth proposition.

This mode is precisely similar to the manner of practical measurement in common life. We apply a foot-rule successively to two lines, and find that thirty applications exhaust the one, whilst it requires thirty-five to exhaust the other. We say, therefore, that the one line is thirty and the other thirty-five feet long; and that these two lines are to each other in the ratio of thirty to thirty-five. Having measured two shorter lines by a similar application of a stick an inch in length, thirty times to the one and thirty-five to the other, we say that the ratio of the two first lines is the same with that of the two last. Euclid has taken this method of demonstrating the fourth proposition of the first book of his celebrated Elements.

But all this process is a fiction of the mind, and it is the fiction of an impossibility: It is even inconceiveable, that is, we cannot in imagination make this application of one figure to another; and we presume to say, that if the elements of geometry cannot be demonstrated in some other way, the science has not that title to pure, abstract, and infallible knowledge which is usually allowed it. We cannot suppose one of the triangles lifted and laid on the other, without supposing it something different from a triangle *in abstracto*. The individuality of such a triangle consists solely in its being in the precise place where it is, and in occupying that portion of space. If we could distinctly conceive otherwise, we should perceive that, when we have lifted the triangle from its place, and applied it to the other, it is gone from its former place, and that there is no longer a triangle there. This is inconceivable, and space has always been acknowledged to be immoveable. There is, therefore, some logical defect in Euclid's demonstration.[2] We apprehend that he is labouring to demonstrate, or rather illustrate, a simple apprehension. This indeed is the utmost that can be done in any demonstration; but the mode by which he guides the mind to the apprehension of the truth of his fourth proposition is not consistent either with pure mathematics or with the laws of corporeal nature. The real process, as laid down by him, seems to be this. We suppose something different from the abstract triangle; something that, in conjunction with other properties, has the property of being triangular, with certain dimensions of two of its sides and the included angle. It has avowedly another property, not essential to, and not contained in,

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[1] To talk intelligibly of the quantity of a pain, we should have some standard by which to measure it; some known degree of it so well ascertained, that all men, when talking of it, should mean the same thing. And we should be able to compare other degrees of pain with this, so as to perceive distinctly, not only whether they exceed or fall short of it, but also how much, or in what proportion; whether by an half, or a fifth, or a tenth.

[2] We do not think so. The demonstration of this and of several other propositions, which form the basis of all the subsequent reasonings of Euclid, rests upon, and, in fact, is nothing more than an appeal to observation, though of the simplest kind; and hence there is no radical or essential distinction between mathematical evidence, and that which we have in the physical sciences, the only difference being that the former proceeds on observations so simple as almost to escape our notice.

Quantity. the abstract notion of a triangle, namely, mobility. We also suppose it permanent in shape and dimensions, or that although, during its motion, it does not occupy the same space, it continues, and so do all its parts, to occupy an equal space. In short, our conception is very mixed, and does not perceptibly differ from our conception of a triangular piece of matter, where the triangle is not the subject, but an adjunct, a quality. And when we suppose the application made, we are not, in fact, supposing two abstract triangles to coincide. This we cannot do with anything like distinctness; for our distinct conception now is, not that of two triangles coinciding, but of one triangle being now exactly occupied by that moveable thing which formerly occupied the other. In short, it is a vulgar measurement, restricted by suppositions which are inadmissible in all actual measurements in the present universe, in which no moveable material thing is known to be permanent, either in shape or magnitude.

This is an undeniable consequence of the principle of universal gravitation, and the compressibility of every kind of tangible matter with which we are acquainted. Remove the brass rule but one inch from its place; its gravitation to the earth and to the rest of the universe is immediately changed, and its dimensions change of consequence. A change of temperature will produce a similar effect; and this is attended to and considered in all nice mensurations. We do the best we can to assure ourselves that our rule always occupies a sensibly equal space; and we must be contented with chances of error which we can neither perceive nor remove.

Were this a proper place, we might take notice of some other logical defects in the reasoning of this celebrated proposition. But they are beside our present purpose of explaining the different modes of mathematical measurement, with the view of discovering that circumstance in which they all agree, and which, if the only one, must therefore be the characteristic of mensuration.

The characteristic notion of mensuration.

We think that the only circumstance in which all modes of mensuration agree, or the only notion that is found in them all, is, that the quantity is conceived as consisting of parts, distinguishable from each other, and separated by assignable boundaries; so that they are at once conceived separately and jointly. We venture to assert that no quantity is directly measured which we cannot conceive in this way, and that such quantities only are the immediate objects of mathematical contemplation, and should be distinguished by a generic name. Let them be called mathematical quantities. Extension, duration, number, and proportion, have this characteristic, and they are the only quantities which have it. Any person will be convinced of the first assertion by attending to his own thoughts when contemplating these notions. He will find that he conceives every one of them as made up of its own parts, which are distinguishable from each other, and have assignable boundaries, and that it is only in consequence of involving this conception that they can be added to or subtracted from each other; that they can be multiplied, divided, and conceived, in any proportion to each other.

He may perhaps find considerable difficulty in acquiring perfectly distinct notions of the mensurability, and the accuracy of the modes of mensuration. He will find that the way in which he measures duration is very similar to that in which he measures space or extension. He does not know, or does not attend to, anything which hinders the brass foot-rule in his hand from continuing to occupy equal spaces during his use of it in measuring the distance of two bodies. In like manner, he selects an event which nature or art can repeat continually, and in which the circumstances which contribute to its accomplishment are invariably the same, or their variations and their effects are insensible. He concludes that it will always occupy an equal portion of time for its accomplishment, or always last an equal time. Then, observing that, during the event whose duration he wishes to measure, this standard event is accomplished twenty-nine and a half times, and that it is repeated 365¼ times during the accomplishment of another event, he affirms that the durations of these are in the ratio of twenty-nine and a half to 365¼. It is thus, and with the same logical defect as in the measuring a line by means of a brass rod, that the astronomer measures the celestial revolutions by means of the rotation of the earth round its axis, or by the vibrations of a pendulum.

For most of the preceding observations we have been indebted to Dr Reid, who published a dissertation on this subject in the forty-fifth volume of the Philosophical Transactions, which we recommend to our philosophical readers as a performance eminent for precision and acuteness. If we presume to differ from him in any trivial circumstance, it is with that deference and respect which all must consider as due to his talents and his fame.

Characters of mathematical quantity.

Dr Reid justly observes, that as nothing has proportion which has not either extension, duration, or number, so the characters of mathematical quantity may be restricted to these three. He calls them *proper* quantities, and all others he calls *improper*. We believe that, in the utmost precision of the English language, this denomination is very apposite, and that the word *quantity*, derived from *quantum*, always supposes measurement. But the word is frequently used in cases where its original sense is not kept in view, and we use other words as synonymous with it, when all mensuration, whether possible or not, is out of our thoughts. According to practice, therefore, the *jus et norma loquendi*, there seems to be no impropriety in giving this name, in our language at least, to whatever can be conceived as great or as little. There is no impropriety in saying that the pain occasioned by the stone is greater than that of the toothach; and when we search for the category to which the assertion may be referred, we cannot find any other than quantity. We may be allowed therefore to say, with almost all our scientific countrymen, that everything is conceivable in respect of quantity which we can think or speak of as greater and less; and that this notion is the characteristic of quantity as a genus, whilst measurableness is the characteristic of mathematical quantity as a species.

But do we not measure many quantities, and consider them mathematically, which have not this characteristic of being made up of their own distinguishable parts? What else is the employment of the mechanician, when speaking of velocities, forces, attractions, repulsions, magnetical influence, chemical affinity, and the like? Are not these mathematical sciences? And if the precision and certainty of mathematics arise from the nature of their specific object, are not all the claims of the mechanician and physical astronomer ill-founded pretensions? These questions require and deserve a serious answer.

Velocity, force, density; how measured.

It is most certain that we consider the notions which are expressed by these terms, velocity, force, density, and the like, as susceptible of measure, and we consider them mathematically. Some of these terms are nothing but names for relations of measurable quantity, and only require a little reflection to show themselves such. *Velocity* is one of these. It is only a name expressing a relation between the space described by a moving body and the time which elapses during its description. Certain moderate rates of motion are familiar to us. But what greatly exceeds this, such as the flight of a bird when compared with our walking, excites our attention, and this excess gets a name. A motion not so rapid as we are familiar with, or as we wish, also gets a name, because in this the excess or defect may interest us. We wish for the flight of the hawk; we chide the tardy pace of our messenger; but it is scientific curiosity which first considers this relation as a separate object of contem-

Quantity. plation, and the philosopher must have a name for it. He has not formed a new one, but he makes use of a word of common language, the natural meaning of which is the combination of a great space with a short time. The philosopher having once appropriated it, in his scientific vocabulary, to this very general use, it loses with him its true signification. Tardiness would have done just as well, though its true meaning is diametrically opposite; and there is no greater impropriety in saying the slowness of a cannon-bullet than in saying the velocity of the hour-hand of a watch. Velocity is a quality or affection of motion, the notion of which includes the notions of space and duration, two mathematical quantities, and no other. It does not therefore express a mathematical quantity itself, but a relation, a combination of two mathematical quantities of different kinds; and as it is measurable in the quantities so combined, its measure must be an unit of its own kind, that is, an unit of space as combined with an unit of time.

Density is another word of the same kind, expressing a combination of space with number. *Densæ arbores* mean trees standing at a small distance from each other; and the word is used in the same sense when we say that quicksilver is denser than water. The expression always suggests to the reflecting mind the notions of particles and their distances. We are indeed so habituated to complicated views of things, that we can see remote connections with astonishing rapidity; and a very few circumstances are sufficient for leading forward the mind in a train of investigation. Common discourse is a most wonderful instance of this. In this way we say, that we found by actually weighing them that inflammable air had not the sixth part of the density of common air. Supposing all matter to consist of equal atoms equally heavy, and knowing that the weight of a bladder of air is the sum of the weights of all the atoms, and also knowing that the vicinity of the atoms is in a certain proportion of the number contained in a given bulk, we affirm that common air is more than six times denser than inflammable air; but this rapid decision is entirely the effect of habit, which renders us familiar with certain groups of conceptions, and we instantaneously distinguish them from others, and thus think and discourse rationally. The Latin language employs the word *frequens* to express both the combination of space and number, and that of time and number.

There are perhaps a few more words which express combinations of mathematical quantities of different kinds; and the corresponding ideas or notions are therefore the proper and immediate subjects of mathematical discussion. But there are many words which are expressive of things, or at least of notions, to which this way of considering them will not apply. All those affections or qualities of external bodies, by which they are conceived to act on each other, are of this kind; impulsive force, weight, centripetal and centrifugal force, magnetical, electrical, chemical attractions and repulsions, in short, all that we consider as the immediate causes of natural phenomena. These we familiarly measure, and consider mathematically.

Forces measured in the phenomena.

What was said on this subject in the article PHYSICS will give us clear conceptions of this process of the mind. These forces or causes are not immediate objects of contemplation, and are known only by and in the phenomena which we consider as their effects. The phenomenon is not only the indication of the agency of any cause, and the characteristic of its kind, but the measure of its degree. The necessary circumstances in this train of human thought are, 1st, The notion of the force as something susceptible of augmentation and diminution; and, 2d, The notion of an inseparable connection of the force with the effect produced, and of every degree of the one with a corresponding degree of the other. From these is formed the notion that the phenomenon or effect is the proper measure of the force or cause. All this is strictly logical.

Quantity.

But when we are considering these subjects mathematically, the immediate objects of our contemplation are not the forces which we are thus treating. It is not their relations which we perceive, and which we combine with such complication of circumstances and certainty of inference as are known in all other sciences. By no means; they are the phenomena only, which are subjects of purely mathematical discussion. They are motions which involve only the notions of space and time; and when we have finished an accurate mathematical investigation, and make our affirmation concerning the forces, we are certain of its truth, because we suppose the forces to have the proportions and relations, and no other, which we observe in the phenomena. Thus, after having demonstrated, by the geometrical comparison of the lines and angles and surfaces of an ellipse, that the momentary deflection of the moon from the tangent of her orbit is the 3600th part of the simultaneous deflection of a stone from the tangent of its parabolic path, Newton affirms, that the force by which a particle of the moon is retained in her orbit is the 3600th part of the weight of a particle of the stone; and having further shown, from fact and observation, that these momentary deflections are inversely as the squares of the distances from the centre of the earth, he affirms that all this is produced by a force which varies its intensity in this manner.

Now all this investigation proceeds upon the two suppositions mentioned above, and the measures of the forces are in fact the measures of the phenomena. The whole of physical astronomy, and indeed the whole of mechanical philosophy, might be taught and understood, without ever introducing the word force, or the notion which it is supposed to express; for our mathematical reasonings are really about the phenomena, which are subjects purely mathematical.

The precision, therefore, which we presume to affirm must attend these investigations, arises entirely from the measurable nature of the quantities that are the real objects of our contemplation, and the suitableness and propriety of the measures which we adopt in our comparisons.

Since, then, the phenomena are the immediate subjects of our discussion, and the operating powers are only inferences from the phenomena considered as effects, the quantity ascribed to them must also be an inference from the quantity of the effect, or of some circumstance in the effect. The measure, therefore, of the cause, or natural power or force, cannot be one of its own parts; for the whole and the part are equally unperceived by us. Our measure, accordingly, must be a measure of some interesting part, or of the only interesting part of the phenomenon. It is therefore in a manner arbitrary, and depends chiefly on the interest we take in the phenomenon. It must, however, be settled with precision, so that all men in using it may mean the same thing. It must be settled, therefore, by the description of that part or circumstance of the phenomenon which is characteristic of the natural power. This description is the definition of the measure.

Measures of centripetal force.

Thus Newton assumes as the measure of his centripetal force, the momentary deviation from uniform rectilineal motion. Others, and sometimes Newton himself, assume the momentary change of velocity, which again is measured by twice this deviation. These measures, being thus selected, are always proper in a mathematical sense, and, if strictly adhered to, can never lead us into any paralogism. They may, however, be physically wrong. There may not be that indissoluble connection between the phenomenon and the supposed cause. But this is no mathematical error, nor does it invalidate any of our mathematical inferences. It only makes them useless for explaining the phenomenon by the principle which we adopted; but it prepares a modification of the phenomenon for some more fortunate application of physical principles.

All that can be desired in the definitions or descriptions

Quantity.

of these measures is, that they may not deviate from the ordinary use of the terms, because this would always create confusion and occasion mistakes. Dr Reid has given an example of an impropriety of this kind, which has been the subject of much debate amongst the writers on natural philosophy; we mean the measure of the force inherent in a body in motion.

Controversy between the Cartesians and Leibnitzians.

Descartes, and all the writers of his time, assumed the velocity produced in a body as the measure of the force which produces it; and observing that a body, in consequence of its being in motion, produces changes in the state or motion of other bodies, and that these changes are in the proportion of the velocity of the changing body, they asserted that there is in a moving body a *vis insita*, an *inherent force*, and that this is proportional to its velocity; saying that its force is twice or thrice as great, when it moves twice or thrice as fast at one time as at another. But Leibnitz observed, that a body which moves twice as fast rises four times as high, against the uniform action of gravity; that it penetrates four times as deep into a piece of uniform clay; that it bends four times as many springs, or a spring four times as strong, to the same degree; and produces a great many effects which are four times greater than those produced by a body which has but half the initial velocity. If the velocity be triple, quadruple, &c. the effects are nine times, sixteen times, &c. greater; and, in short, are proportional, not to the velocity, but to its square. This observation had been made before by Dr Hooke, who enumerated a prodigious variety of important cases in which this proportion of effect is observed. Leibnitz, therefore, affirmed that the force inherent in a moving body is proportional to the square of the velocity.

It is evident that a body, moving with the same velocity, has the same inherent force, whether this be employed to move another body, to bend springs, to rise in opposition to gravity, or to penetrate a mass of soft matter. Therefore these measures, which are so widely different, whilst each is agreeable to a numerous class of facts, are not measures of this something inherent in the moving body which we call its force, but are the measures of its exertions when modified according to the circumstances of the case; or, to speak still more cautiously and securely, they are the measures of certain classes of phenomena consequent upon the action of a moving body. It is in vain, therefore, to attempt to support either of them by a demonstration. The measure itself is nothing but a definition. The Cartesian calls that a double force which produces a double velocity in the body upon which it acts. The Leibnitzian calls that a quadruple force which makes a quadruple penetration. The reasonings of both in the demonstration of a proposition in dynamics may be the same, as also the result, though expressed in different numbers.

But the two measures are far from being equally proper; for the Leibnitzian measure obliges us to do continual violence to the ordinary use of words. When two bodies moving in opposite directions meet, strike each other, and stop, all men will say that their forces are equal, because they have the best test of equality which we can devise. Or when two bodies in motion strike the parts of a machine, such as the opposite arms of a lever, and are thus brought completely to rest, we and all men will pronounce their mutual energies by the intervention of the machine to be equal. Now, in all these cases, it is well known that a perfect equality is found in the products of the quantities of matter and velocity. Thus a ball of two pounds, moving with the velocity of four feet in a second, will stop a ball of eight pounds moving with the velocity of one foot per second. But the followers of Leibnitz say that the force of the first ball is four times that of the second.

All parties are agreed in calling gravity an uniform or invariable accelerating force; and the definition which they give of such a force is, that it always produces the same acceleration, that is, equal accelerations in equal times, and therefore produces augmentations of velocity proportional to the times in which they are produced. The only effect ascribed to this force, and consequently the only thing which indicates, characterises, and measures it, is the augmentation of velocity. What is this velocity, considered not merely as a mathematical term, but as a phenomenon, or as an event produced by the operation of a natural cause? It cannot be conceived any other way than as a determination to move on for ever at a certain rate, if nothing shall change it. We cannot conceive this very clearly. We feel ourselves forced to animate, as it were, the body, and give it not only a will and intention to move in this manner, but a real exertion of some faculty in consequence of this determination of mind. We are conscious of such a train of operations in ourselves; and the last step of this train is the exertion or energy of some natural faculty, which we, in the utmost propriety of language, call force. By such analogical conception, we suppose a something, an energy, inherent in the moving body; and its only office is the production and continuation of this motion, as in our own case. Scientific curiosity was amongst our latest wants, and language was formed long before its appearance. As we formed analogical conceptions, we contented ourselves with the words already familiar to us, and to this something we gave the name *force*, which expressed that energy in ourselves which bears some resemblance, in office at least, to the determination of a body to move on at a certain rate. This sort of allegory pervades the whole of our conceptions of natural operations, and we can hardly think or speak of any operation without a language, which supposes the animation of matter. And in the present case there are so many points of resemblance between the effects of our exertions and the operations of nature, that the language is most expressive, and has the strongest appearance of propriety. By exerting our force we not only move and keep in motion, but we move other bodies. In like manner, a ball not only moves, but puts other bodies in motion, or penetrates them. This is the origin of that conception which so forcibly intrudes itself into our thoughts, that there is inherent in a moving body a force by which it produces changes in other bodies. No such thing appears in the same body if it be not in motion. We therefore conclude that it is the production of the moving force, whatever that has been. If so, it must be conceived as proportional to its producing cause. Now this force, thus produced or exerted in the moving body, is only another way of conceiving that determination which we call velocity, when it is conceived as a natural event. We can form no other notion of it. The *vis insita*, the determination to move at a certain rate, and the velocity, are one and the same thing, considered in different relations.

Vis insita.

Therefore the *vis insita corpori moventi*, the determination to move at a certain rate, and the velocity, should have one and the same measure, or any one of them may be taken as the measure of the other. The velocity being an object of perception, is therefore a proper measure of the inherent force; and the propriety is more evident by the perfect agreement of this use of the words with common language. For we conceive and express the action of gravity as uniform, when we think and say that its effects are proportional to the times of its action. Now all agree that the velocity produced by gravity is proportional to the time of its action. And thus the measure of force, in reference to its producing cause, perfectly agrees with its measure, independent of this consideration. But this agreement is totally lost in the Leibnitzian doctrine; for the body which has fallen four times as far, and has sustained the action of gravity twice as long, is said to have four times the force.

The quaintness and the continued paradox of expression

Quantity. Conservatio virium vivarum.

which this measure of inherent force leads us into, would have quickly exploded it, had it not been that its chief abettors were leagued in a keen and acrimonious warfare with the British mathematicians who supported the claim of Sir Isaac Newton to the invention of fluxions. They rejoiced to find in the elegant writings of Huygens a physical principle of great extent, such as this, which could be set in comparison with some of the wonderful discoveries in Newton's *Principia*. The fact, that in the mutual action of bodies on each other the product of the masses and the squares of the velocities remain always the same, which they call the *conservatio virium vivarum*, is of almost universal extent; and the knowledge of it enabled them to give ready and elegant solutions of the most abstruse and intricate problems, by which they acquired a great and deserved celebrity. Dr Robert Hooke, whose observation hardly anything escaped, was the first who remarked,[1] long before Huygens, that in all the cases of the gradual production and extinction of motion, the sensible phenomenon is proportional to the square of the produced or extinguished velocity.

Law of continuity.

John Bernoulli brought all these facts together, and systematized them according to the principle advanced by Huygens in his treatise on the centre of oscillation. He and Daniel Bernoulli gave most beautiful specimens of the prodigious use of this principle for the solution of difficult physical problems, in their dissertations on the motion and impulse of fluids, and on the communication of motion. It was, however, very early objected to them, that in the collision of bodies perfectly hard there was no such *conservatio virium vivarum;* and that in this case the forces must be acknowledged to be proportional to the velocities. The objections were unanswerable. But John Bernoulli evaded their force, by affirming that there were not and could not be bodies perfectly hard. This was the origin of another celebrated doctrine, on which Leibnitz greatly plumed himself; namely, the law of continuity, that nothing is observed to change abruptly, or *per saltum*. But no one will pretend to say that a perfectly hard body is an inconceivable thing; on the contrary, all will allow that softness and compressibility are adjunct ideas, and not in the least necessary to the conception of a particle of matter, nay totally incompatible with our notion of an ultimate atom.

Great superiority of Newton.

Sir Isaac Newton never could be provoked to engage in this dispute. He always considered it as a wilful abuse of words, and unworthy of his attention. He guarded against all possibility of cavil, by giving the most precise and perspicuous definitions of those measures of forces, and of all other quantities which he had occasion to consider, and by carefully adhering to them. And in one proposition of about twenty lines, namely, the thirty-ninth of the first book of the *Principia*, he explained every phenomenon adduced in support of the Leibnitzian doctrine, showing them to be the immediate consequences of the action of a force measured by the velocity which it produces or extinguishes. There it appears that the heights to which bodies will rise in opposition to the uniform action of gravity are as the squares of the initial velocities; so are the depths to which they will penetrate uniformly resisting matter, and so is the number of equal springs which they will bend to the same degree. We have had frequent occasion to mention this proposition as the most extensively useful of all Newton's discoveries. It is that which gives the immediate application of mechanical principles to the explanation of natural phenomena. It is incessantly employed in every problem by the very persons who hold by the other measure of forces, although such conduct is virtually giving up that measure. They all adopt, in every investigation, the two theorems $f\dot{t} = \dot{v}$, and $f\dot{s} = v\dot{v}$; both of which suppose an accelerating force f proportional to the velocity v which it produces by its uniform action during the time t; and the theorem $\boldsymbol{f} f\dot{s} = v^2$ is the thirty-ninth of the first book of the *Principia*, and is the *conservatio virium vivarum*.

Quantity || Quarles.

This famous dispute, the only one in the circle of mathematical science, has led us somewhat aside. But we have little more to remark with respect to measurable quantity. We cannot say what varieties of quantity are susceptible of strict measure, or that it is impossible to give accurate measures of everything susceptible of augmentation and diminution. We affirm, however, with confidence, that pain, pleasure, joy, and the like, are not made up of their own parts, which can be contemplated separately; but they may chance to be associated by nature with something that is measurable, and we may one day be able to assign their degrees with as much precision as we now ascertain the degrees of warmth by the expansion of the fluid in the thermometer. There is one sense in which they may all be measured, viz. numerically, as Newton measures density, *vis motrix*, and so forth. We can conceive the pain of each of a dozen of men to be the same. Then it is evident that the pain of eight of these men is to that of the remaining four as two to one; but from such mensuration we do not foresee that any benefit is likely to arise.

QUANTITY, in *Grammar*, is an affection of a syllable, by which its measure, or the time it occupies in pronunciation, is ascertained; or that which determines the syllable to be long or short.

Quantity is also the object of prosody, and distinguishes verse from prose; whilst the economy and arrangement of quantities, that is, the distribution of long and short syllables, constitutes what is called *number*.

Quantities are usually distinguished amongst grammarians by the characters of short and long. There is also a common, variable, or dubious quantity; that is, syllables which are at one time taken for short, and at another time for long ones.

QUARANTINE is a trial which ships must undergo when suspected of pestilential infection. It may be ordered by the king, with advice of the privy-council, at such times, and under such regulations, as he judges proper. Ships ordered on quarantine must repair to the place appointed, and continue there during the time prescribed; and they must have no intercourse with the shore, except for necessary provisions, which are conveyed with every possible precaution. When the time is expired, and the goods have been opened and exposed to the air as directed, if there be no appearance of infection, they are admitted to port. See PLAGUE.

QUARLES, FRANCIS, the son of James Quarles, clerk to the board of green cloth, and purveyor to Queen Elizabeth, was born in 1592. He was educated at Cambridge, became a member of Lincoln's Inn, and was for some time cup-bearer to the queen of Bohemia, and chronologer to the city of London. It was probably on the ruin of the queen's affairs that he went to Ireland as secretary to Archbishop Usher; but the troubles in that kingdom forced him to return; and not finding affairs more settled in England, some disquiets he met with were thought to have hastened his death, which happened in 1644. His works, both in prose and in verse, are numerous, and were formerly in great esteem, particularly his Divine Emblems; but the obsolete quaintness of his style has caused them to fall into neglect, excepting amongst particular classes of readers. "The memory of Quarles," says Headley, "has been branded with

[1] *Micrographia, vis restitutiva*, &c. in his Posthumous Works.

Quarnaro ‖ Quarter.

more than common abuse, and he seems to have been censured merely from the want of being read. If his poetry failed to gain him friends and readers, his piety should at least have secured him peace and good will. He too often, no doubt, mistook the enthusiasm of devotion for the inspiration of fancy. To mix the waters of Jordan and Helicon in the same cup, was reserved for the hand of Milton; and for him, and him only, to find the bays of Mount Olivet equally verdant with those of Parnassus. Yet, as the effusions of a real poetical mind, however thwarted by untowardness of subject, will seldom be rendered totally abortive, we find in Quarles original imagery, striking sentiment, fertility of expression, and happy combinations; together with a compression of style that merits the observation of the writers of verse. Gross deficiencies of judgment, and the infelicity of his subjects, concurred in ruining him."

QUARNARO, the collective name of some islands situated on the coast of Austrian Dalmatia, in a gulf near to Istria, which is secure as a harbour. The whole of these islands are fertile and well cultivated. The largest of them, Arbe, contains 3000 inhabitants; the next in size, Pago, has 4000. One important product, salt, is made in many lagunes by the power of the sun. The inhabitants of these islands are a mixed race, consisting of Italians and Sclavonians, and not too much civilized.

QUARRY, a place under ground, from which are extracted marble, freestone, slate, limestone, or other matters proper for building.

QUARRY, or *Quarrel*, amongst glaziers, means a pane of glass cut in the form of a diamond.

Quarries are of two kinds, square and long, each of which is of a different size, and expressed by the number of the pieces that make a foot of glass, viz. eighths, tenths, eighteenths, and twentieths; but all the sizes are cut to the same angles, the acute angle in the square quarrels being 77° 19′, and in the long ones 67° 21′.

QUARRY, amongst hunters, is sometimes used for a part of the entrails of the beast taken, which is given by way of reward to the hounds.

QUARRY, in falconry, is the game which the hawk is in pursuit of, or has killed.

QUART, a measure of capacity, being the fourth part of some other measure. The English quart is the fourth part of the gallon, and contains two pints.

QUARTAN, a measure containing the fourth part of some other measure.

QUARTAN, a species of intermitting fever.

QUARTATION is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus when gold alloyed with silver is to be parted, we are obliged to facilitate the action of the aquafortis, by reducing the quantity of the former of these metals to one fourth part of the whole mass; which is done by sufficiently increasing the quantity of the silver, if it be necessary. This operation is called quartation, and is preparatory to the parting; and many authors even extend this name to the operation of parting.

QUARTER, the fourth part of any thing, the fractional expression for which is $\frac{1}{4}$.

QUARTER, in weights, is generally used to signify the fourth part of an hundredweight avoirdupois, or twenty-eight pounds. Quarter, used as the name of a dry measure, is the fourth part of a ton in weight, or eight bushels.

QUARTER, a term in the manège. To work from quarter to quarter, is to ride a horse three times in upon the first of the four lines of a square, then changing your hand, to ride him three times upon the second, and so to the third and fourth, always changing hands, and observing the same order.

QUARTERS, with respect to the parts of a horse, is employed in various senses. Thus the shoulders and fore-legs are called the *fore-quarters*, and the hips and hinder-legs the *hind-quarters*. The quarters of a horse's foot are the sides of the coffin, comprehending between the toe and the heel; the *inner* quarters are those opposite to one another, facing from one foot to the other, and these are always weaker than the *outside* quarters, which lie on the external sides of the coffin. *False-quarters* are a cleft in the horn of a horse's hoof, extending from the coronet to the shoe. A horse is said to be a *quarter-cast* when, for any disorder in the coffin, we are obliged to cut one of the quarters of the hoof.

Quarter ‖ Quartetto.

QUARTER, in *Astronomy*, the fourth part of the moon's period. Thus, from the new moon to the quadrature is the first quarter; from this to full moon, the second quarter; and so on.

QUARTER, in *Heraldry*, is applied to the parts or members of the first division of a coat that is quartered, or divided into quarters.

Franc QUARTER, in *Heraldry*, is a quarter single or alone, which possesses one-fourth part of the field. It forms one of the honourable ordinaries of a coat.

QUARTER of a Ship, that part of a ship's side which lies towards the stern, or which is comprehended between the aftmost end of the main chains and the sides of the stern, where it is terminated by the quarter-pieces.

QUARTER-Master, an officer whose principal business it is to look after the quarters of the soldiers, their clothing, bread, ammunition, firing, and the like.

QUARTER-Master-General is an important officer in the army, and should not only be a man of great judgment and experience, but well skilled in geography. His duty is to mark out the marches and encampments of an army; and therefore he should know the country perfectly well, with its rivers, plains, marshes, woods, mountains, defiles, and passages, nay, even the smallest accident of the ground. Prior to a march, he receives the order and route from the general commanding, and appoints a place for the quarter-masters of the army to meet him next morning, with whom he marches to the next camp, where, having viewed the ground, he marks out to the regimental quarter-masters the ground allowed each regiment for their camp; he chooses the head-quarters, and appoints the villages for the generals of the army's quarters; he appoints a proper place for the encampment of the train of artillery; he conducts foraging parties, as likewise the troops to cover them against assaults, and has a share in regulating the winter-quarters and cantonments. See ARMY.

QUARTER-Sessions, a general court which is held quarterly by the justices of peace of each county.

QUARTERS, a name given at sea to the several stations where the officers and crew of a ship of war are posted in action.

QUARTERS, at a siege, the encampment upon one of the principal passages round a place besieged, to prevent relief and convoys.

Head-QUARTERS of an Army, the place where the commander-in-chief has his quarters.

Intrenched QUARTERS, a place fortified with a ditch and parapet, to secure a body of troops.

Winter QUARTERS sometimes means the space of time included between leaving the camp and taking the field; but more properly the places where the troops are quartered during the winter.

QUARTETTO, *Quartet*, in music, a composition for four voices, or for four instruments, in which the parts are all *obbligati*; that is, in which no one of the parts can be omitted without injuring the proper effect of the composition. To understand the structure of instrumental quartettos of this kind, those of Haydn, Mozart, Beethoven, Spohr, Onslow, and a very few others, must be examined. Vocal quartettos are generally accompanied by instruments, to

Quartile ‖ Quebec.

sustain the voices. A mere interchange of melody between one part and another, where the parts alternately become principal and subordinate, without any interweaving of them by means of imitations, double counterpoint, &c. does not constitute a regular quartetto. Neither is a regular quartetto found in a composition that consists of one principal part, accompanied from beginning to end by three other parts, which are merely harmonic supports to the principal part. See MUSIC and PRINCIPAL.

QUARTILE, an aspect of the planets when they are at the distance of ninety degrees from each other, and which is denoted by the character □.

QUARTERING, in *Heraldry*, is dividing a coat into four or more quarters or quarterings, by parting, couping, and otherwise, that is, by perpendicular and horizontal lines.

QUARTO-DECIMANS, an ancient sect in the Christian church, who taught that Easter should always be celebrated according to the custom of the Jews, on the fourteenth day of the moon in the month of March, whensoever that day might fall out; and hence they derived their name, *quarto-decimani*, or fourteenth-men. The Asiatics were mightily attached to this opinion, pretending that it was built on the authority of St John, their apostle; and Pope Victor could never bring them to obedience in this article, though he was upon the point of excommunicating them.

QUARTU, a city of the island of Sardinia, in the diocese of Cagliani. It stands on a bay of the same name. Though many of the houses are respectable, they are all built of bricks dried by the sun. The walls of the church-yard are strangely decorated with skulls and thigh-bones. The situation is tolerably healthy. The inhabitants amount to 5129.

QUATRE-BRAS, a village of the Netherlands, in the circle of Nivelles, receiving its name from two great roads crossing each other at this point, where there is a direction-post with four arms. It is worthy of remark as the spot where the first meeting took place between the British and French troops two days before the decisive battle of Waterloo. This contest was obstinate and bloody, and the loss on both sides heavy, whilst the success was doubtful. The British received there the intelligence of the defeat of the Prussians at Ligny; and their artillery not being come up, they retreated the next day to the field of Waterloo, where they completed the work of the campaign. The reigning duke, Frederick William of Brunswick, fell in the attack of the French on his troops.

QUATUORVIR, in *Antiquity*, formerly written IIII. VIR, a Roman magistrate, who had three colleagues joined with him in the same administration, and had the care of conducting and settling the colonies sent into the provinces. There were also quatuorviri appointed to inspect and take care of repairs.

QUAVER, in *Music*, a measure of time equal to half a crotchet, or an eighth part of a semibreve.

QUEBEC, the capital of Lower Canada, is situated upon the north-eastern extremity of a promontory called Cape Diamond, three hundred and fifty feet above the water level, on the left bank of the river St Lawrence. The rocky ridge upon which the city stands is formed by the St Lawrence and the St Charles, the former river flowing to the southward of Quebec, and the latter to the northward, and the junction taking place in front of the town, where they expand into a considerable basin forming the harbour of Quebec. The distance from the one river to the other, across the ridge, is rather more than a mile. It is divided into two parts, Upper and Lower Quebec. The latter is built at the base of the promontory, nearly on a level with high-water mark. The communication from this to the upper town is by a long, narrow, winding, and extremely steep street, which terminates close to the city walls, at an elevation of two hundred feet above the river. Here Upper Quebec commences, extending its limits considerably to the westward along the slope of the ridge, and up the promontory towards the cape, within fifty or sixty yards of its summit, which is crowned by the citadel. This part of the town contains the government buildings, the residence of the governor, the military, and the most opulent of the inhabitants, with the best and handsomest streets, and the most agreeable mansions. The lower town is much more crowded and mean in appearance, and is very filthy and inconvenient. The streets are narrow, the foot-pavement being barely sufficient for a single passenger; the houses have a gloomy and monotonous aspect, and many of them are said to be built of wood, although there exists a statute forbidding the use of this material in the construction of the main part of buildings, as a security against the dreadful conflagrations which have so often desolated the cities of the west. The warehouses are built of stone; and this ill-favoured portion of Quebec is the chief seat of the commerce and traffic by which the city is enriched. Amongst the public buildings may be mentioned the castle of St Louis, a huge vice-regal chateau, supported by piers, and overhanging the precipice; the Hotel Dieu, the Protestant and Catholic cathedrals, and a number of other religious edifices; the exchange, bank, court-house, hospitals, barracks, gaol, and others. There is a French seminary or college, containing usually about two hundred pupils, and other establishments connected with education. In the district of Quebec there are five public or free schools, in the district of Montreal twenty-four, and in the district of Three Rivers six public schools, under the superintendence of the Board of Royal Institution for the Advancement of Learning, incorporated by the provincial act 41st Geo. III. cap. 17. To this board the legislature makes an annual grant. Each teacher is bound to instruct one third of the number of pupils gratuitously, and in no case to charge more than three shillings and fourpence per month. The visitors may vary the rate according to the number of children in each family who attend school, and the circumstances of the parents. There are also two grammar-schools, one at Quebec and another at Montreal, supported by an annual grant of L.200 each from the Jesuit Estates Fund, with L.90 and L.50 respectively for house-rent. These are also under the superintendence of the Royal Institution. The system of instruction is that of the public grammar schools of England. Twenty-six free scholars are admitted into each of them. The rate of tuition for others is L.12 per annum. There are also upwards of a thousand schools established under the provincial act 9 Geo. IV. cap. 46, attended by about 45,600 scholars of both sexes. L.20 are allowed to each teacher having at least twenty children under his care. These schools are under the direction of trustees annually elected by the inhabitants. No particular system of tuition is followed, but the Lancasterian is pursued in a few of them. There are also several Roman Catholic colleges in the province, and a number of private seminaries for the higher branches of education. Besides these, there were in Lower Canada, in 1835, 1170 elementary schools, attended by 21,014 boys and 16,654 girls, of whom 12,495 were taught gratis, and 25,173 were paid for. The houses were mostly roofed with shingles, but many of those of a better sort, and the public buildings and great warehouses, are covered with tin or iron plates. There are several distilleries, breweries, tobacco, soap, candle, and other manufactories. Excellent ships are built here, and every variety of tradesmen may be found in the upper or lower town. Many of the shops, or stores as they are called in America, are elegantly fitted up, and well supplied with every commodity in demand. There are suburbs attached to each town.

Quebec.

One of the leading features of Quebec is its fortifications, it being the strongest place in America. "As a fortress," says Mr Montgomery Martin, "Quebec may now be ranked in the first class, the citadel, on the highest point of

Quebec. Cape Diamond, together with a formidable combination of strongly constructed works, extending over an area of forty acres. Small batteries, connected by ramparts, are continued from the edge of the precipice to the gateway leading to the lower town, which is defended by cannon of a large calibre, and the approach to it up Mountain Street (which connects the upper and lower town) enfiladed and flanked by many large guns. A line of defence connects with the grand battery a redoubt of great strength, armed with twenty-four pounders, entirely commanding the basin and passage of the river. Other lines add to the impregnability of Quebec if properly defended, the possession of which may be said to give the mastery of Upper as well as of Lower Canada." To the west, and in front of the citadel, are the celebrated plains of Abraham, where was achieved the victory which wrested Canada from France, and annexed it to the British empire. An obelisk marks the field where Wolf and Montcalm fought and perished. The basin or harbour of Quebec is very beautiful, safe, and spacious, being sufficient to contain a hundred sail of the line. The river St Lawrence is twelve miles broad above the city, but is here contracted to one mile in breadth. The commerce of Quebec is considerable, indeed nine tenths of the trade of Canada is carried on from this city. The imports consist of British manufactures, wine, rum, and other spirits, sugar, coffee, tea, salt, and tobacco. The exports, the produce of the Canadas, are ships' masts, spars, timber, various kinds of prepared wood, pot and pearl ash, fish, oil, seal-skins, pork, beef, butter, lard, live-stock, hides, castoreum, capillaire, natural curiosities, wheat, Indian corn, and the like, as also furs; and there is likewise a re-exportation of British fabrics, West India produce, and teas. The imports into Lower Canada, during the year 1835, amounted to L.1,496,376, and the exports to L.896,847, of which L.7750 was for fish, L.30,590 for corn, and L.620,182 for wood. The amount of the paper currency in 1835 was L.268,881, of which L.52,535 was in notes of the Quebec bank, and L.216,346 in notes of the Montreal bank. The following table shows the amount of shipping in 1835.

Countries.	Inwards.					
	Quebec.		Montreal.		St John's.	
	Ships.	Tons.	Ships.	Tons.	Ships.	Tons.
Great Britain.....	869	277,125	78	19,984	...	...
British colonies...	186	21,158	27	2,524	4	340
United States.....	24	6,507	1	155	1324	69,086
Foreign states....	26	6,700	2	210	...	...
Total.....	1105	311,490	108	22,873	1328	69,426
Men employed...	13,425		1134		3422	
	Outwards.					
Great Britain.....	946	300,097	69	17,893	...	...
British colonies...	186	14,003	28	2,767	4	320
United States.....	4	397	8	1,678	820	68,607
Foreign states....	8	1,477	1	263	...	...
Total.....	1144	315,974	106	22,601	824	68,927
Men employed...	13,614		1103		2909	

Emigration to Quebec was for many years carried on to a great extent; the number of arrivals in the year 1832 being 51,746. The recent disturbances in Canada, and the opening up of a new field for emigration in Australasia, have combined to check the influx of Europeans, so that in the year 1836 they had diminished to 27,728, in 1837 to 22,500, and in 1838 to only 4992. The seasons of Quebec may be briefly noticed. Winter sets in towards the close of November, and for several weeks heavy falls of snow, hail, and sleet, follow each other in rapid succession. Quebec. The snow falls very deep, and it is often a difficult matter to keep even a narrow pathway open. Towards the end of December the weather clears, and the solid sheet of snow which covers the surrounding country becomes enlivened by multitudes of citizens, who now sally forth with horse, sledge, and carriole, and drive along the smooth and shining plain. In March the weather gets mild, and even hot, and in April the ice of the St Lawrence breaks with a mighty crash. May and June are generally wet; but July and August are marked by intense heat and the plague of insects. September is the most agreeable month; but, in October, winter returns "to rule the inverted year." Quebec was settled by the French in the year 1608; taken by the English, first in 1629, and afterwards in 1759; and finally ceded to us by the treaty of Paris in 1766. In 1776 an unsuccessful attack was made upon it by the Americans under General Montgomery, who fell, together with about 7000 men. The population of Quebec in 1825 amounted to 20,396, and in 1831 to 25,916. Long. 70. 72. W. from Greenwich, Lat. 46. 48. N.

Since the article Canada in this work made its appearance, a revolution has broken out in that part of the British empire, and proved of so serious a nature as to cause a considerable loss of life both in the field and upon the scaffold. It is not our purpose to enter into minute details regarding either the origin of the revolt or the course of events. A brief statement of the leading facts is all that can be given here. Since this colony was annexed to the British crown, two parties have existed in it, the French, the original settlers, or their descendants; and the British, or their descendants, who were the subjugators of the province. The two races have never amalgamated, but, on the contrary, their animosity to each other has been aggravated by recent circumstances to such a degree, that it is constantly in danger of breaking out in acts of open hostility. Although the British race are possessed of the greatest wealth, intelligence, and enterprise, the French Canadians have always been by far the most numerous class, and, on the ground of their numerical superiority, they aspire to have the leading sway in the affairs of the province. But, as the government of Canada is constituted, this has been found impossible; for although they may preponderate in the lower house or house of assembly, they are checked by the legislative council, the members of which are not popularly elected, but chosen by the governor in the name of the sovereign of Great Britain. It is alleged by the house of assembly that abuse of power has resulted from this mode of election; that extreme partiality to the British, and neglect of the French, has been shown, not only in the formation of the legislative council itself, but in the distribution of government appointments. Amongst the grievances of which they complained were, the tenures act, the want of control over the public revenue of the province, and others, which were embodied in a document transmitted to the imperial government in 1832–33. This memorial consisted of ninety-two resolutions, and was drawn up by the leading men of the house of assembly. The substance of them was as follows: 1*st*, That the legislative council should be elective; 2*dly*, that the executive council should be converted into a ministry, responsible to the assembly; 3*dly*, that the tenures act and land company's act should be repealed; 4*thly*, that the crown revenues should be surrendered unconditionally; 5*thly*, that the management of the waste lands should be given up to them. And they further declared, that they would pay no arrears, nor vote any civil list, until these demands should be complied with. The arrears spoken of were the salaries of public functionaries, which for several years had remained unpaid, being stopped by the members of assembly. The delegates from Canada met with a patient hearing from the committee appointed

Quebec.

to investigate the subject; but the British government refused to accede to the propositions, and a series of resolutions were carried in parliament, the substance of which is as follows: 1*st*, That whilst no change could be made in the mode of electing the legislative council, it was expedient to adopt measures for securing to it a higher degree of public confidence; 2*dly*, that whilst it was expedient to improve the composition of the executive council, it was unadvisable to render it responsible to the assembly; 3*dly*, that the title of the land company was to remain inviolate; 4*thly*, "that as soon as the legislative shall make provisions by law for discharging lands from feudal dues and services, and for removing any doubts as to the incidents of the tenure of land, in free and common soccage, it is expedient to repeal the Canada tenures act, and the Canada trade act, so far as the latter relates to the tenures of land in this province, saving, nevertheless, to all persons the rights vested in them under or in virtue of those acts;" 5*thly*, that provision should be made for paying arrears due; and, lastly, "that it is expedient that the legislatures of Lower and Upper Canada respectively be authorized to make provision for the joint regulation and adjustment of questions respecting their trade and commerce, and of other questions wherein they have a common interest.[1]

On the 18th of August 1837, an extraordinary session of the parliament of Lower Canada was called together by Lord Gosford, the governor-in-chief; but the assembly again refused all supplies, and continued to decline exercising any legislative functions. Confusion and disorganization now began to spread throughout the whole social as well as political system of Canada. On the 23d of October, a meeting of delegates, named by the different parishes in five counties, was held at St Charles, in Lower Canada. The persons assembled were addressed by Papineau, speaker of the house of assembly, and other individuals, and a series of resolutions were passed expressing dissatisfaction with the manner in which Canada was governed. That same day a meeting of the friends of the constitution was held at Montreal, and resolutions were passed in favour of supporting the government, and condemnatory of the revolutionary movements. Disaffection now assumed the shape of insurrection, and anarchy was immediately followed by bloodshed. The insurrection was suppressed without much difficulty; but the country still remains in a very unsettled condition. (R. R. R.)

Queckni ‖ Queda.

QUECKNI, a town of the Birman empire, in the province of Martaban, and situated between the sea and a range of mountains to which it gives name. Long. 97. 45. E. Lat. 15. 35. N.

QUEDA, or QUEDAH, a country of Asia, and a Malay principality, situated on the west coast, between the fifth and eighth degrees of north latitude, immediately opposite to Prince of Wales Island. It extends about 150 miles along the coast, between 5° 10′ and 7° 30′ of north latitude, and stretches inland from twenty to twenty-five miles. Along the shore, for a distance of about twenty-four leagues, there are numerous islands, that shelter the coast, which is low and covered with woods. The water, to a great distance from the shore, is extremely shallow, with sand-banks, so that ships are obliged to anchor at a great distance from the shore. Twenty-three rivers, all deep enough for prows, and some for larger vessels, empty themselves into the sea. The

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[1] Nothing has given rise to greater discontent and heart-burnings than the provision made for the support of the church by means of portions of land set apart for this purpose. The grants of land, as a reward for public services, have likewise been considered as very injurious. This cannot be better explained than in the words of Lord Durham, in his Report on the affairs of British North America.

"The system of clergy reserves was established by the act of 1791, commonly called the Constitutional Act, which directed that, in respect of all grants made by the crown, a quantity equal to one seventh of the land so granted should be reserved for the clergy. A quantity equal to one seventh of all grants would be one eighth of each township, or of all the public land. Instead of this proportion, the practice has been, ever since the act passed, and in the clearest violation of its provisions, to set apart for the clergy in Upper Canada a seventh of all the land, which is a quantity equal to a sixth of the land granted. There have been appropriated for this purpose 300,000 acres, which, legally, it is manifest, belong to the public. And of the amount for which clergy reserves have been sold in that province, namely, L.317,000 (of which about L.100,000 have been already received and invested in the English funds), the sum of about L.45,000 should belong to the public.

"In Lower Canada the same violation of the law has taken place, with this difference, that upon every sale of crown and clergy reserves, a fresh reserve for the clergy has been made, equal to a fifth of such reserves. The result has been the appropriation for the clergy of 673,567 acres, instead of 446,000, being an excess of 227,559 acres, or half as much again as they ought to have received. The Lower Canada fund already produced by sales amounts to L.50,000, of which, therefore, a third, or about L.16,000, belong to the public. If, without any reform of this abuse, the whole of the unsold clergy reserves in both provinces should fetch the average price at which such lands have hitherto sold, the public would be wronged to the amount of about L.280,000; and the reform of this abuse will produce a certain and almost immediate gain to the public of L.60,000. In referring, for further explanation of this subject, to a paper in the appendix, which has been drawn up by Mr Hanson, a member of the commission of inquiry which I appointed for all the colonies, I am desirous of stating my own conviction that the clergy have had no part in this great misappropriation of the public property, but that it has arisen entirely from heedless misconception, or some other error, of the civil government of both provinces.

"The great objection to reserves for the clergy is, that those for whom the land is set apart never have attempted, and never could successfully attempt, to cultivate or settle the property, and that, by that special appropriation, so much land is withheld from settlers, and kept in a state of waste, to the serious injury of all settlers in its neighbourhood. But it would be a great mistake to suppose that this is the only practice by which such injury has been, and still is, inflicted on actual settlers. In the two Canadas especially, the practice of rewarding, or attempting to reward, public services by grants of public land, has produced, and is still producing, a degree of injury to actual settlers which it is difficult to conceive without having witnessed it. The very principle of such grants is bad, inasmuch as, under any circumstances, they must lead to an amount of appropriation beyond the wants of the community, and greatly beyond the proprietor's means of cultivation and settlement. In both the Canadas, not only has this principle been pursued with reckless profusion, but the local executive governments have managed, by violating or evading the instructions which they received from the secretary of state, to add incalculably to the mischiefs that would have arisen at all events.

"In Upper Canada, 3,200,000 acres have been granted to 'U. E. Loyalists,' being refugees from the United States, who settled in the province before 1787, and their children; 730,000 acres to militiamen, 450,000 acres to discharged soldiers and sailors, 255,000 acres to magistrates and barristers, 136,000 acres to executive councillors and their families, 50,000 acres to five legislative councillors and their families, 36,900 acres to clergymen as private property, 264,000 acres to persons contracting to make surveys, 92,526 acres to officers of the army and navy, 500,000 acres for the endowment of schools, 48,520 acres to Colonel Talbot, 12,000 acres to the heirs of General Brock, and 12,000 acres to Doctor Mountain, a former bishop of Quebec; making altogether, with the clergy reserves, nearly half of all the surveyed land in the province. In Lower Canada, exclusively of grants to refugee loyalists, as to the amount of which the crown lands' department could furnish me with no information, 450,000 acres have been granted to militiamen, to executive councillors 72,000 acres, to Governor Milne about 48,000 acres, to Mr Cushing and another upwards of 100,000 acres (as a reward for giving information in a case of high treason), to officers and soldiers 200,000 acres, and to 'leaders of townships' 1,457,209 acres; making altogether, with the clergy reserves, rather more than half of the surveyed lands originally at the disposal of the crown."

Quedlinburg || Queen Charlotte's Islands.

town is called Queda by strangers. It is situated in latitude 6° north, upon one of the largest rivers, which is navigable for vessels of 300 tons burden, and is 300 yards in width at the mouth, where was formerly a brick fort, now in ruins. The entrance into this river is choked up by a flat mud-bank, over which, at spring tides, there is only nine feet water. The road where the ships anchor is about two leagues from the shore. The town of Queda formerly contained about 300 houses, inhabited by Chinese, Chulias, and Malays; and it enjoyed a considerable trade; but since the establishment of Pulo Pinang, the Malay prows have chiefly resorted to the latter place. Allistar, seven miles up the river, is the residence of the king, to which place all vessels can ascend when their draught enables them to pass the bar. The river here is narrow, but deep; and both shores are muddy, swampy, and covered with jungle. A little above Allistar the ground rises, and the river is then only navigable for prows. There are in the interior tin-mines, the produce of which is conveyed to the coast by the Qualla Moorba, a rapid and shallow stream, yet navigable for small craft. The exports of this district consist of elephants' teeth, wax, &c., but principally tin, which are chiefly exchanged for opium and Spanish dollars. The king, as in most of these eastern countries, engrosses the chief share of the trade. In 1786 an agreement was made with the king of Queda for the cession of Pulo Pinang or Prince of Wales Island; and in 1792 a regular treaty was concluded on the subject, by which the East India Company agreed to pay 6000 dollars annually whilst they retained possession of the island. A new treaty was made in 1802, for the cession of additional territory, which tract of country the company engaged to protect from all enemies, robbers, and pirates. The free exportation of provisions and other articles to Prince of Wales Island was also agreed on, besides a clause for the apprehension and delivery of insurgents, felons, debtors, and slaves; in consideration of which the company agreed to pay 10,000 dollars annually, as long as they held possession of the island and the coast.

QUEDLINBURG, a city of the Prussian province of Saxony, situated on the river Bode, which was formerly the capital of an independent ecclesiastical state, under the abbess of that name. It contains eight Catholic churches, is surrounded with walls, and has an ancient palace, with an extensive library, 1720 houses, and 11,500 inhabitants. There are extensive breweries and distilleries, and various manufactures of woollen and linen goods. Long. 11. 32. 39. E. Lat. 51. 47. 48. N.

QUEEN, a woman who holds a crown singly in her own right. The title of queen is also given by way of courtesy to her who is married to a king, and called by way of distinction queen-consort, the former being termed queen-regent. The widow of a king is also called queen, but with the addition of dowager.

QUEEN CHARLOTTE'S ISLANDS, a group of islands lying in front of that part of the north-western coast of America called New Hanover, between the fiftieth and fifty-fourth parallels of north latitude. Cook observed these islands, but supposed that they formed portions of the continental shore. They were discovered by La Pérouse, who named them the Fleurieu Islands, an appellation of which they were unintentionally deprived by Vancouver, who called them after the princess-royal of England. The largest island is of a triangular form, about one hundred and seventy miles in length, and in some parts sixty miles in breadth, and is separated from the main land by a broad channel or arm of the sea. The southern promontory of this island was named Cape Hector by La Pérouse, and Cape St James by Vancouver. The latter navigator coasted along the shore, and found that near the sea the land was moderately elevated, but that towards the interior it rose into rugged and uneven mountains. Of the Indians who inhabit it little is known, and that little is significant of their being pretty low in the scale of intelligence.

Queen Charlotte's Island || Queen's County.

QUEEN CHARLOTTE'S *Island*, in the Pacific, six miles in length and one in breadth, was discovered in 1767 by Captain Wallis. Long. 138. 4. W. Lat. 19. 18. S.

QUEEN CHARLOTTE'S *Sound*, a bay at the north end of the southern island of New Zealand, where Captain Cook erected a post with an union flag. The entrance is situated in long. 184. 45. W. and lat. 41. S.

QUEEN'S COUNTY, an inland county in the province of Leinster, in Ireland, is bounded on the north by the King's County, on the east by those of Kildare and Carlow, on the south by those of Carlow and Kilkenny, and on the west by Tipperary and the King's County. It extends over a surface of 396,810 acres, of which 335,838 are cultivated, and 60,972 are uncultivated mountain and bog.

No notice of the inhabitants of this part of Ireland is to be found in Ptolemy's account of the island; but Whitaker supposes it to have been peopled, together with all the other interior parts, by the Scots. It was afterwards known by the names of Ossory and Leix; the former consisting of the north-western districts, the latter of the remainder of the county, and the Barrow constituting the boundary between them. Ossory, of which the Macgillypatricks or Fitzpatricks were the toparchs, ranked as a subordinate kingdom at the landing of the English, and for some time afterwards. Leix was made a county palatine, which fell into the possession of Roger Mortimer through the female line, and afterwards was seized on by the O'Mores, who retained possession of it, and proved persevering and troublesome enemies to the English government, until the reign of Philip and Mary, when the territory was made shire-ground, under the name of the Queen's County, in honour of the sovereign; and the place chosen for the county town was named Maryborough, for the same reason. This county, when brought under British law, was gradually peopled by English settlers. During the subsequent reigns several of these families have become extinct in the male line, and others were expelled or extinguished by the confiscations arising out of the civil wars in 1641 and 1689, whilst the descendants of others, the principal of whom are the Veseys, Cootes, Parnells, Dawsons, and Burrowes, still retain the whole or some portion of their ancestral possessions. It is now divided into the baronies of Ballyadams, Cullinagh, Maryborough East, Maryborough West, Partnehinch, Slievemarigue or Slievemargy, Stradbally, Tinnehinch, and Upper Ossory. These are subdivided into thirty-eight parishes, and six parts of parishes the remaining parts of which are in the adjoining counties. According to the ecclesiastical arrangements of the country, the county contains fifty-one parishes, of which twenty-seven are in the diocese of Leighlin, fifteen in that of Ossory, seven in Kildare, and one each in Killaloe and Dublin.

The general face of the country is level, but it rises into heights of considerable elevation in the Slieve-Bloom Mountains, which, taking a direction nearly north and south along the western verge of the county, rise to a considerable height, their most elevated point being 1689 feet above the level of the sea, and with an acclivity so abrupt that the only practicable road across them is through the pass of Glandine. In the southern extremity the Slievemarigue Hills, of considerably inferior elevation, separate the county from that of Kilkenny. But the general surface of the country is not, strictly speaking, level; the monotony of a perfect plain is relieved by a range of low hills, which traverse it in a direction from north to south, and the most remarkable of which are the Rock of Dunamase and the Dun of Clopoke; as also by eskars, a singular species of low hills, or rather slight elevations of the surface, formed of rounded pebbles, apparently forced together by the operation of contending currents of water. The most remarkable of these is the Ridge of Maryborough, which, enter-

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ing from the King's County, proceeds for a considerable distance by Maryborough, and, after having been deranged and broken, resumes again the form of a continuous ridge, branching out in the southern part of the county in two divisions. The Slieve-Bloom Mountains give rise to some of the great rivers of Ireland. The Barrow rises at their northern extremity, and, after passing through the north of the county, forms its north-eastern boundary; then, turning southwards, it forms its boundary to the east, separating it from Kildare and Carlow, and falls into the Suir some miles below New Ross, forming with that river the estuary called Waterford Harbour. The source of the Nore is southward of that of the Barrow, in the same mountains. It passes through the south-western part of the county by Abbeyleix and Ballynakill, enters the county of Kilkenny near Ballyragget, and, after flowing by the city of Kilkenny, joins the Barrow about two miles above New Ross. The portion of the Barrow between its junction with the Nore and Suir is generally called the Ross River. The Suir, which also rises in the Slieve-Bloom Mountains at their southern extremity, does not belong to this county. The smaller rivers are the Ownas, Trihogue, and Blackwater, tributaries of the Barrow; and the Tonnet, Dolore, Old Forge River, Cloncoose, Cromoge, Corbally, Trumry, Colt, and Erkin, tributaries of the Nore. The Barrow is navigable for barges from Athy, where it is connected with the Grand Canal from Dublin to New Ross, and thence to the sea for vessels of 500 tons. The Nore is not navigable until after it has quitted the county. There is no lake except that of Annagh on its northern boundary, which partly belongs to the King's County, the line of demarcation between the two counties being drawn through the middle of it.

The amount of the population, according to the calculations made at different periods, some founded on conjectural estimates, others on actual enumeration under legislative authority, is as follows:—

Year.	Authority.	No. of Souls.
1760	De Burgo	53,604
1792	Beaufort	82,000
1812	Parliamentary return	113,857
1821	Ditto	134,275
1831	Ditto	145,843

The return of 1831 gives an average of one inhabitant to every 2·72 acres, or of one to every 2·30 cultivated acres. The returns of the Commissioners of Public Instruction in 1834, being made up in dioceses, do not give the population of counties with strict accuracy; yet they afford data sufficient to show the comparative numbers of the three great divisions of the people with respect to their several religious persuasions. If the entire population of the county be estimated at 150,000, the number of Episcopalian Protestants would amount to 20,000, of Protestant dissenters to 1000, and of Roman Catholics to 129,000; according to which calculation, the Protestants would be to the Catholics as one to six nearly.

The county returned eight members to the Irish parliament; two for the county at large, and two each for the boroughs of Portarlington, Maryborough, and Ballynakill. This number was reduced to three by the act of union, by which the boroughs were disfranchised, with the exception of the first named, which still continues to return one member. The number of registered electors for the county, according to the latest return, was 2150, that of the borough of Portarlington 156. The election for the county takes place at Maryborough. The local government consists of a lieutenant, eighteen deputy-lieutenants, all appointed by the crown during pleasure, and ninety magistrates (including the lieutenants) appointed by the lord-chancellor, and holding office during good behaviour. The constabulary force consists of a sub-inspector, eight chief constables, ten head-constables, thirty-seven constables, and two hundred and seventy-six sub-constables; in all, 332.

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The state of education, according to the parliamentary returns in 1821 and 1824–26, was as follows:

Year.	Boys.	Girls.	Sex not ascertained.	Total.
1821	4825	1998		6,823
1824–6	6624	4908	231	11,763

Of the numbers stated in the latter of these returns, 2074 were Episcopalian Protestants, 104 Protestant dissenters, and 9426 Roman Catholics; the religious persuasion of the remaining 305 not having been ascertained. The total number of schools was 275; of which thirty-five, containing 2150 pupils, were maintained by grants of public money; twenty-four, containing 1625 pupils, by the voluntary contributions of societies or individuals; and the remaining 216 schools, which afforded the means of education to 7988 pupils, wholly by the fees of the pupils. The Report of the Commissioners of National Education in 1837 (the latest published), states the number of schools, teachers, and pupils connected with their board as follows: Schools, 18; teachers, 20; boys, 1323; girls, 1045; total of pupils, 2368.

The level part of the county forms the southern portion of the great flœtz limestone field which traverses Ireland across its centre. The peculiar flatness of the interior appears to have caused those accumulations of alluvial matter, composed of clay and limestone gravel, which, in the form of low but steep ridges of hills, occur so frequently throughout the midland districts, and are known by the name of eskars. Some very striking specimens of this formation in the county have already been noticed. That the surface of the country was exposed to the action of rapid currents of water, is evidenced by the deep parallel indentations or furrows frequently observable on the surface of rocks from which the alluvial soil has been removed. It is also probable that the gravel hills were rapidly deposited from water in violent action; an inference which is confirmed by the fact, that they mostly consist of large masses of rock partially rounded, intermixed with small gravel, and even with clay and sand. The sandstone shows itself in the Slieve-Bloom Mountains, which are almost wholly of that formation. The south-eastern extremity forms a small part of the Leinster coal-field, the mineral in it being, like that of Kilkenny, which adjoins it, of the carbonaceous or stone-coal formation, the slaty glantz-coal of Werner, burning dully with little flame, emitting an offensive and unwholesome vapour, and therefore disagreeable for domestic use, but excellent for malting or for the forge, for both which purposes it is in such demand that its high price, were there no other objection to it, prevents it being much used for family purposes even in the neighbourhood. Iron was raised here, and the works were carried on as long as the forests afforded materials for fuel. Potters' earth is also raised, and applied, in the neighbourhood of Mountmellick, to the manufacture of the coarser kinds of earthen wares.

The soil varies greatly in different parts. Where it rests on the limestone substratum, it consists mostly of a stiff clay loam, well adapted for the growth of wheat; in other parts it is light and sandy, and produces good crops of oats and barley. The mountain district is wet and boggy even in the higher parts, the clayey sub-soil not admitting free passage for the water, which therefore accumulates on the surface; and it is also much encumbered with rock. The low hills that traverse the middle of the county from north to south are capable of culture mostly to their summits, and, where not deemed suitable for the plough, afford rich pasturage for sheep. The tracts on the sides of the rivers, being annually flooded by the overflowings of the stream during winter, form rich meadow-land. Bogs are frequent in most parts, supplying ample material of fuel for domestic purposes. The county was once so thickly wooded as to be al-

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most impenetrable for the passage of large bodies of men; and thence, as well as from the bogs, which, from a different cause, were also difficult to be crossed by those not well acquainted with their peculiarities, the natives were enabled to hold out long against the attempts of the English settlers. But the old woods have long since been cleared away, the only proof of their former existence being discoverable in the numerous remains of timber-trees lying in the bottom of Lough Annagh. A new growth, however, the offspring, not of the unaided efforts of nature, but of the hand of modern improvement, has in a great measure restored one of its most beautiful and useful features. Large plantations, chiefly around the demesnes of the gentry, vary the prospects, and tend much to relieve the monotony of the level surface. Most parts present the mansions and seats of resident proprietors; comfortable farm-houses are numerous, and much attention has been paid by many landlords to excite amongst their tenantry a laudable emulation in the neatness of their cottages, and in the judicious cultivation of their little farms. The coal district must, however, form an exception to this general description. In it, notwithstanding the superior means of procuring domestic comforts, through the high wages and constant employment afforded by the collieries, the appearance of the peasantry, both in their persons and dwellings, exhibits too frequent instances of the destitution consequent on confirmed habits of reckless improvidence. With the exception of the lands held by wealthy proprietors in their own hands, and those in the mountainous parts, where grazing is the chief object, the farms are not large, seldom more than from ten to fifteen acres. Wheat is very extensively grown, its culture being more and more attended to even on those soils which, during the more confined state of agricultural knowledge, were thought to be unfit for it. The lighter soils answer well for barley and oats. Potatoes are everywhere raised, both for family use and for feeding cattle; forming also an essential part of the improved rotation system, which is generally practised. Green crops, particularly turnips, are not unusual, and the value of every kind of clover seems to be duly appreciated. Much attention is given to the introduction of implements and machines of the best description; the clumsy and inartificial vehicles, ploughs, and harrows, formerly in use, being scarcely to be met with except in districts little capable of being brought into profitable agricultural production. The breed of every kind of cattle has been improved during the last twenty or thirty years, to a degree that scarcely could have been anticipated at the commencement of the period. Dairies are numerous and highly productive. Butter is the produce chiefly attended to; and large quantities of it are prepared for export. Cheese is seldom made. The rich low lands graze black cattle of large size. In a word, the county, with the exception already noticed, appears to be rapidly advancing in improvement throughout every department of rural economy, from the nobleman's demesne to the humble garden of the cottier tenant.

From the preceding statement it may easily be inferred that the character of the population is almost exclusively agricultural. The only place in which manufactures have at all succeeded is Mountmellick. Several branches of the woollen, linen, and cotton trade have been undertaken there, but without much success; coarse woollens and cottons for the supply of the surrounding districts being the only kinds fabricated. Tanning is carried on to some extent; flour-mills are large and numerous; and there are some extensive distilleries and breweries. The Grand Canal, a branch of which has been carried from Monasterevin to Mountmellick, conveys much of the produce of the county to Dublin, either for sale there or for export. The Barrow serves the same purpose with respect to Waterford. The mail-coach roads from Dublin to Cork and Limerick traverse the county. There are many remains of ancient edifices, both ecclesiastical and military. Amongst the most remarkable of the former is that of Aghaboe, once the seat of the bishopric of Ossory; the ruins of Aghmacart, and of several others of lesser note, are still visible. The site of the abbey of Timahoe can be ascertained only by the pillar-tower there, which is supposed to have stood in its immediate vicinity. Of the military antiquities the most ancient is a fortress placed upon the summit of a hill in the south-west of the county, and called Bawnachra; it consists of a circular enclosure surrounded by a rampart and fosse. The ancient fortress of Dunamase, situated on the summit of a precipitous hill rising abruptly from the middle of a large plain, and once the chief residence of the O'Mores, presents a very picturesque appearance. Lea Castle, a few miles distant, on the Barrow, a place of considerable strength, was taken and dismantled by Cromwell. Burros-in-Ossory on the Nore, and Castlecuffe in Tinnehinch, built by the celebrated republican leader Sir Charles Coote, were also places of considerable strength. Amongst the modern mansions, that of the Earl of Portarlington, at Ems, is the most splendid.

Maryborough, the county town, situated nearly in the centre of the county, on one of the small feeders of the Barrow, presents few features to arrest attention, beyond those public edifices to which the transaction of county business and the claims of religion give rise. It was a borough entitled to send representatives to parliament; but this, the only important privilege to a small town, having been abolished at the union, the other corporate functions became paralyzed, and are now virtually extinct. The county court-house is a neat building; and the prison, on the radiating plan, lately built at an expense of L.19,000, affords accommodation for 121 prisoners. The state of crime, as far as it is deducible from the number of convictions, is not favourable. In 1837 the convictions were 214, of which five were capital, but commuted into a lesser punishment; eight were for transportation for life, and fifteen for seven years. The district lunatic asylum for the King's, Queen's, Westmeath, and Longford counties is fixed here; and it affords accommodation for 156 patients, who are maintained in it at an average expense of L.19 per head. The flour trade is the only manufacture of any extent. The population in 1831 was 3220. That of the other towns having upwards of 1000 inhabitants each was in the same year respectively as follows:—Mountellick, 4577; Portarlington, originally a settlement of French refugees, and till lately of some note as a place of elementary education, 3091; Mountrath, 2593; Graige, which is, strictly speaking, a suburb of Carlow, though in a different county, 1976; Ballynakill, 1927; Stradbally, near which is the Dun of Clopoke, an isolated rock, perforated by subterraneous cavities, 1799; Ballycollinbeg, 1381; Rathdowney, 1214; and Abbeyleix, which, though amongst the smallest, is the neatest in external appearance, 1009.

Queenborough || Queensferry.

QUEENBOROUGH, a town of the county of Kent, in the Isle of Sheppey, at the mouth of the river Medway, forty-five miles from London. It was an ancient borough, and returned two members to the House of Commons till 1832, when it was disfranchised. It is governed by a mayor and jurats. The chief employment is the oyster fishery. The population amounted in 1801 to 545, in 1811 to 805, in 1821 to 881, and in 1831 to 786.

QUEENSFERRY, South, a royal burgh and parish in the county of Linlithgow, Scotland. It is situated on the south side of the Frith of Forth, nine miles west from Edinburgh, and consists of one irregular street of a mean appearance, from which branch various narrow alleys. The town is a place of considerable antiquity, having been in early times a burgh of regality, held under the abbey of Dunfermline. It obtained the privileges of a burgh of regality from Malcolm IV., which were confirmed by David II. and afterwards by Charles I.; and in the year

Queiling ‖ Quesnay.

1633 the burgh sent its first commissioner to the Scottish parliament. In 1641, by act of parliament, it was dismembered from the parish of Dalmeny, and erected into a separate parish. Before the union it possessed a considerable trade, but what it now has depends on a soap-work, a brewery, and a distillery. The regular ferry is at Newhall, a little to the east of the town, where the frith contracts to one and a half mile in breadth. It is under the direction of trustees; and, in addition to the sail-boats, a steam-vessel, carrying the mail, plies regularly at all times of the tide. There are at both sides low-water piers, on which the passengers are landed, and excellent inns for their accommodation. The revenue of the burgh is about L.88, arising from customs, anchorages, shore-dues, and other small items; and its permanent expenditure is L.70. 2s. The revenue for 1837-38 amounted to L.135. It is governed by a provost, three bailies, a treasurer, a dean of guild, and fifteen councillors, and, with Culross, Dunfermline, Inverkeithing, and Stirling, returns a member to parliament. The population in the year 1821 amounted to 690, and in 1831 to 684.

QUEILING, or KOUELING, a city of China, of the first rank, and capital of the province of Quangsee. It is situated on the banks of a rapid river. Long. 109. 51. E. Lat. 25. 12. N.

QUELPAERT, an island in the Eastern Seas, to the north of the peninsula of Corea. A Dutch vessel was wrecked here in 1635, called the Sparrow-Hawk, commanded by Henry Hamel, by whom the knowledge of this island was first brought to Europe. Long. 126. 35. E. Lat. 33. 14. N.

QUENTIN, ST, an arrondissement of the department of the Aisne, in France. It extends over 430 square miles, comprising ten cantons, divided into 121 communes, with 91,200 inhabitants. The capital is a city of the same name, situated on a hill, at the foot of which flows the Somme, which is joined by two inland canals. It is strongly fortified, and has a fine old cathedral and good market-place, 1650 houses, and 10,740 inhabitants, who have been long celebrated for their fabrics of fine linens, especially cambrics and lawns, and thread-lace. These trades have, however, of late years declined, the manufactures of cotton have been substituted, and, now that spinning-mills have been at work, many muslins and fine calicoes are produced. Near this city was fought, in 1557, a great battle between the French and Spaniards. Long. 3. 12. 18. E. Lat. 49. 50. 51. N.

QUESAN, a cluster of small islands situated off the eastern coast of China, and attached to the province Tchekiang. The most southerly, called by the British sailors Patchcock, is situated in long. 120. 52. E. and lat. 29. 22. N.

QUESNAY, FRANÇOIS, a physician of considerable eminence, but who is chiefly known in the history of philosophy as a profound and ingenious inquirer into the constitution of society, and as the founder of the sect of the Economists.

The accounts of the life of this distinguished person, which, unlike that of most literary men, abounded in incident and adventure, are exceedingly meagre and contradictory. Neither the place of his birth nor the condition of his parents has been well ascertained; but the accounts apparently most entitled to credit state that he was born at the village of Ecquivilly, in the Isle de France, in 1694; and that his father was either a common labourer, or a small proprietor who cultivated his own little property.[1] His humble origin is indeed evident from the fact mentioned by all his biographers, of his early education having been almost entirely neglected, and of his being constantly occupied, until his fourteenth or sixteenth year, in the sports or labours of the fields, without being either sent to school or taught to read. But although placed in such unfavourable circumstances, young Quesnay was imbued with an ardent love of knowledge, and with a strong desire to emerge from the obscure station in which he had been brought up. The *Maison Rustique* of Liebaut was the first book that came into his hands; and he is said to have learned to read it by the assistance of lessons given him by a gardener of the village. The perusal of this book, which seems to have had a material influence over his future studies, awakened his latent powers, and stimulated him to make further efforts to extend his information. Having acquired a competent knowledge of his vernacular tongue, by the eager reading of such French books as came into his hands, he next applied himself to the study of the dead languages; and speedily attained, partly by the slender assistance of a self-dubbed surgeon of the village, but chiefly by his own extraordinary industry and sagacity, to a tolerable proficiency in Latin and Greek. Quesnay.

Quesnay now resolved, in opposition to the wishes of his parents, and especially of his mother, to devote himself to the profession of surgery, and received the rudiments of his instruction in that art from the village-doctor who had assisted him in his philological studies. But the pupil very soon surpassed the master; and when the latter applied to be admitted into the *Maitrise*, or Corporation of Surgeons, he presented, as testimonials of his skill in his profession, and of his capacity to practise it with advantage, some Essays written by Quesnay, and which were received with very great applause. Quesnay was not privy to this *ruse*; but soon after its occurrence he left his paternal village, and set out to prosecute his studies at Paris. We are not informed by what means he supported himself in that city, nor how long he remained there; but his indefatigable industry and zeal enabled him to make great progress in his studies, whilst his merit and modesty procured him several friends. Besides attending prelections on the various branches of surgery, and the different hospitals, he found leisure to devote some portion of his time to metaphysical researches, and the study of philosophy, for which the perusal of the *Recherche de la Vérité* of Malebranche had given him a very decided taste. Nay, such was the almost unparalleled activity and vigour of his mind, that having accidentally met, during his stay in Paris, with the celebrated M. Cochin, of the Royal Academy of Painting, he put himself under his tuition; and we are told, that he profited so well by the few lessons he received, as to be able not only to take remarkably good likenesses, but to design and *engrave*, with his own hand, the various bones of the human skeleton, in a manner which would not have disgraced the most skilful artists.

On finishing his studies at Paris, Quesnay formed the design of establishing himself as a surgeon in Mantes, a considerable town of his native province, and presented himself to the surgeons of its *Maitrise* for examination. But they refused, from jealousy, as is alleged, of his talents, to admit him to trial. He was thus laid under the necessity of returning to Paris, where he passed his examinations with éclat; and in 1718 received letters ordering him to be admitted into the *Maitrise* of Mantes.

Having established himself at Mantes, his reputation soon extended itself. He was employed by some of the first

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[1] It is stated in the *Eloge Historique* of Quesnay, in the *Mémoires de l'Académie des Sciences* for 1774, that he was the son of an *advocat en Parlement* at Montfort, and that he was born at Merey. But it is difficult to suppose, had his father been in such a station, that his education should have been so entirely neglected. In the brief but interesting notice of Quesnay, given by Mr Crawfurd in a note to the *Journal* of Madame du Hausset, femme-de-chambre of Madame de Pompadour, et *l'amie* de Quesnay, in the *Mélanges d'Histoire et de Littérature* (p. 276), he is stated to have been the son of a labourer. This also is the statement of the *Encyclopédie Méthodique*. According to the *notice* prefixed by Dupont to the *Eloge* of M. Gournay, in the third volume of the *Œuvres de Turgot*, Quesnay was the son *d'un propriétaire cultivateur*.

Quesnay. families of the neighbourhood, and, amongst others, by that of the Marshal de Noailles, Duc de Villeroi, who persuaded him to leave his residence in the country, and to accompany him to Paris as his surgeon, as nearly as we can collect in 1729 or 1730. An incident not long afterwards occurred, which had the most material influence over his future prospects and life. Having accompanied the Duc de Villeroi to the house of the Comtesse d'Estrades, Quesnay remained behind in the carriage whilst the duke went in to visit that lady, who, during the interview, was suddenly seized with an epileptic fit. Quesnay being called in, and perceiving the nature of the attack, with singular presence of mind ordered the duke and the other attendants out of the room, and managed so well as to succeed in concealing the nature of the malady. The comtesse was so much pleased with this dexterity and address, that she lost no time in recommending Quesnay to her all-powerful friend, Madame d'Estioles, afterwards Madame de Pompadour, who made him her physician; and, besides obtaining for him apartments at Versailles, procured him, in 1737, the place of surgeon in ordinary to the king.[1]

Quesnay was shortly afterwards appointed secretary to the Royal Academy of Surgery, established in 1731; and, besides several articles on particular branches of surgery, he contributed the preface to the first volume of its *Mémoires*, which has always been reckoned peculiarly valuable for its profound and discriminating observations on the respective uses of theory and observation in the physical sciences, and on the assistance they reciprocally lend to each other.

Having from an early period been much subject to the gout, and becoming in consequence less able to discharge his duties as surgeon, Quesnay took the degree of doctor of medicine in 1744; and was soon afterwards appointed, through the influence of his powerful patroness, to the important place of consulting physician to the king. In this capacity he attended Louis in the campaigns of 1744 and 1745, and, amid the distractions of a camp, collected and prepared the greater part of the materials for his *Traité de Fièvres*, published in 1753.

His appointment as physician to the king was preceded by the grant of letters of nobility, issued on the recovery of the dauphin from an attack of small-pox. Louis, who was much struck with the justice and solidity of Quesnay's remarks, familiarly called him *son penseur*, and gave him, in allusion to this title, three pansey flowers (in French, *pensées*), for his arms, with the motto *Propter cogitationem mentis.*

The leisure Quesnay now enjoyed enabled him to prosecute his studies with greater assiduity. In 1747 he republished an enlarged edition, in three tomes 12mo, of his *Essai Physique sur l'Economie Animale*, originally published in 1736; in 1748 he published an *Examen Impartiel des Contestations des Médécins et des Chirurgiens de Paris;* in 1749 he published a *Mémoire sur la Sagesse de l'Ancienne Législation de la Chirurgie en France*, and two separate treatises in 12mo, the one on Suppuration, and the other *De la Gangrène;* in 1750 he republished his *Traité des Effets et de l'Usage de la Saigné*, written during his residence at Mantes, and originally published in 1730; and in 1753 he published his *Traité des Fièvres Continués*, two tomes 12mo.

These works have all been held in very high estimation; and an excellent judge has given it as his opinion, that "the *Traité de la Gangrène* is by far the most valuable publication which we yet possess upon this subject." Every page of this work, he adds, "is distinguished by the same talent for accurate observation and perspicuous arrangement, which are so remarkable in all the other writings of this celebrated author." (Thomson's *Lectures on Inflammation*, p. 502.) Quesnay.

The *Traité des Fièvres* was the last of Quesnay's professional works. He appears to have thenceforth comparatively abandoned his medical studies. At no period, indeed, had he allowed them to occupy exclusively his attention; and he now devoted himself, in preference, to other, and, if possible, still more interesting inquiries. He had always entertained a strong predilection for agricultural pursuits, the effect, perhaps, of his situation in early life; and this, combined with the speculative and metaphysical cast of his mind, seems to have led him to those peculiar notions respecting the paramount importance of agriculture as a source of wealth, and the constitution of society, which have rendered his name so justly celebrated in the history of economical science. The articles *Fermier* and *Grains* in the *Encyclopédie*, published in 1756 and 1757, contain the earliest development of his views on this subject. They are both written with great ability, and display an intimate acquaintance with the subject, considerable reading, and great powers of analysis. In the article *Grains* the distinction between the *produit total* and the *produit net;* between the productiveness of agriculture and the supposed unproductiveness of other employments, with the doctrine of the unrestricted freedom of commerce, and most of the other leading principles in the theory of the economists; are distinctly stated, and illustrated with much ingenuity. The *Tableau Economique*, and the *Maximes Générales du Gouvernement Economique*, annexed to it under the title of *Extraits des Economies Royales de M. de Sully*, were printed, by command of the king, at Versailles, in the year 1758, with the following very remarkable epigraph for a work brought forth under such auspices, *Pauvres paysans, pauvre royaume; pauvre royaume, pauvre souverain.* The Maxims, which contain a short but comprehensive abstract of Quesnay's system, were reprinted, together with an analysis of the *Tableau*, and a selection from various articles contributed by Quesnay, in explanation and defence of his peculiar doctrines, to the *Journal d'Agriculture*, and the *Ephémérides du Citoyen*,[2] in the collection of Quesnay's economical works, entitled *Physiocratie, ou Constitution Naturelle du Gouvernement le plus Avantageux au Genre Humain*, edited by his friend and scholar Dupont in 1767.

We have elsewhere entered at considerable length into an examination of the speculations of Quesnay and his followers, with respect to the constitution of political societies and the sources of public wealth. (See Economists and Political Economy.) That there is a good deal of error in them must be allowed; but this is far more than countervailed by the many just, discriminating, and original views and important discoveries which they contain. Perhaps, however, the principal merit of Quesnay and his followers does not consist so much in the discoveries they made, as in their having been the first philosophers who distinctly perceived that the institutions of society should always harmonize with the natural principles on which it is founded, or, as they termed it, with the *ordre naturel et essentiel des sociétés politiques.* According to them, econo-

[1] This incident is related by Mr Crawford, *Mélanges*, p. 276, and is referred to by Marmontel.

[2] The *Ephémérides du Citoyen*, begun in 1767, was, for a few months, conducted by the Abbé Baudeau, and then by Dupont. It appeared monthly, and two numbers make a considerable 12mo volume. The authors were disciples of Quesnay, and zealous economists. Their discussions embraced the moral and political sciences, many branches of which they have treated with much ability and acuteness. There is a valuable *Eloge* of Quesnay in one of the numbers for 1775, written by Count d'Albon. The following extract from the *approbation* given by the *Censeur* to the third number for 1770 is curious: "J'exhorte de nouveau les auteurs de ce *Journal*, à résister à la tentation de critiquer. Le bonheur du citoyen tient à sa confiance. On peut et l'on doit quelquefois avertir en secret ceux qui sont préposés à l'administration. *Mais on ne doit prêcher aux particuliers que leur propre réforme, et non celle de l'état.*"

Quesnay. mical science is "*L'étude et la démonstration des loix de la nature rélatives à la subsistence et la multiplication du genre humain.* L'observation universelle de ces loix est l'intérêt commun et général de tous les hommes. La connaissance universelle de ces loix est donc le préliminaire indispensable et le moyen nécessaire du bonheur de tous." (*Ephémérides du Citoyen*, 1769, No. II. p. 13.) It is to be regretted that, in investigating these laws, they proceeded too much upon abstract and speculative principles, without sufficiently attending to the effects of particular institutions, and to the various phenomena manifested in the progress of society. But notwithstanding the defective mode in which they conducted their researches, they succeeded in establishing and elucidating many important principles; and there is certainly much more reason to wonder at the general correctness of their conclusions, than to feel surprised at the errors into which they fell. Quesnay and his disciples established, that society either is or should be formed to secure the greatest possible advantage to its members; that the security of property and the freedom of industry are its essential bases; and that, instead of interfering to regulate the pursuits of individuals, the proper business of the politician is to protect the equal rights and liberties of all, and to secure the utmost freedom of competition in every department of industry. And though it be undoubtedly true that most of these principles had been pointed out by previous writers, Quesnay and his school have the merit of being the first who showed their dependence on each other, and who, by presenting them in a systematic and consecutive form, were enabled to give a scientific demonstration of the injustice and impolicy of such institutions as ignorance or mistaken views of national interest had established in opposition to them.

In the article Political Economy an attempt has been made to show the fallacy of Quesnay's opinion with respect to agriculture being the only source of wealth; and the experience of all ages sufficiently proves that the *despotisme légal*, in the hands of an hereditary monarch, without *contreforces* of any kind, which he strangely supposed was the best of all possible governments, is about the very worst.[1]

Notwithstanding his great age, and the sufferings he experienced from almost incessant attacks of the gout, the activity of Quesnay's mind continued unimpaired. "*Il a*," said one of his friends, "*une tête de trente ans sur un corps de quatre-vingts.*" He contributed subsequently to the publication of the *Physiocratie*, many acute and able articles to the *Ephémérides du Citoyen*, and continued wholly occupied with these studies, and with mathematics, to which he latterly began to pay considerable attention, until his death, which took place at Versailles in December 1774, in the eightieth year of his age.

Quesnay possessed inflexible integrity, a nice sense of honour, and great prudence and discretion. Though highly esteemed by the king, and long resident at court, he never intermixed in the intrigues of which it was the constant theatre. No one ever scrupled to express himself freely in his presence; nor was this confidence ever betrayed. "Il récevoit chez lui des personnes de tous les partis, mais en petit nombre, et qui toutes avoient une grande confiance en lui. *On y parloit très hardiment de tout; et ce qui fait leur éloge et le sien, jamais on n'a rien répété.*"[2] To the utmost frankness and sincerity he added the easy address and polish of a courtier, and the intelligence of a philosopher. No man could be less solicitous of distinguishing himself, or more careful not to offend the self-esteem of others. His conversation was animated, without the least effort at brilliancy. So much indeed was he averse from every appearance of pretension, that he was in the habit of veiling the most profound remarks and observations under the form of apologues, which generally referred to some subject connected with rural affairs, to which he was always particularly attached. He was most indulgent to the faults and errors of others, provided they were unalloyed by any taint of artifice or baseness, for which he never hesitated, whatever might be the rank of the party, to express the utmost contempt. Quesnay was truly a patriot and a philosopher; and it would be difficult to produce another instance of one who, having lived long in a profligate and luxurious court, unsullied by its vices, and aloof from its contentions, preserved to an extreme old age all those generous and kindly feelings, with that unobtrusive but ardent zeal in the cause of humanity, and that love of speculation and profound inquiry, which distinguished his earlier years. Quesnay.

"Quesnay," says Madame du Hausset, "étoit un grand génie, suivant l'opinion de tous ceux qui l'avoit connu, et de plus un homme fort gai. Il aimoit causer avec moi de la campagne; j'y avois été élevée, et il me faisoit parler des herbages de Normandie et du Poitou, de la richesse des fermiers, et de la manière de cultiver. C'étoit le meilleur homme du monde, et la plus éloigné de la plus petit intrigue. Il étoit bien plus occupé à la cour de la meilleure manière de cultiver la terre que de tout ce que s'y passoit." (*Mélanges*, p. 343.)

"Tandis," says Marmontel, "que les orages se formoient et se dissipoient au-dessous de l'entresol de Quesnay, il griffonnoit ses axiomes et ses calculs d'économie rustique, aussi tranquille, aussi indifférent à ces mouvemens de la cour, que s'il en eût été à cent lieues de distance. Là bas, on décidoit de la paix, de la guerre, du choix des généraux, du renvoi des ministres; et nous, dans l'entresol, nous raisonnions d'agriculture; nous calculions le *produit net*, ou quelquefois nous dînions gaiement avec Diderot, d'Alembert, Duclos, Helvétius, Turgot, Buffon; et Madame de Pompadour, ne pouvant pas engager cette troupe de philosophes à descendre dans son salon, venoit elle-même les voir à table, et causer avec eux."

Dr Smith was well acquainted with Quesnay. He frequently met him during his residence at Paris in 1766; and whilst he bears the most honourable testimony to the "modesty and simplicity" of his character, he has pronounced his system to be, "with all its imperfections, the nearest approximation to the truth that has yet been published on the subject of political economy." (Wealth of Nations, p. 307.) So highly, indeed, was Smith impressed with a sense of his merits as a man and a philosopher, that it was his intention, had he not been prevented by Quesnay's death, to have inscribed to him the Wealth of Nations. (Dugald Stewart's Account of the Life and Writings of Dr Smith.)

Quesnay had a son by his wife, to whom he was united when at Mantes. He gave him an excellent education; and exhibited a striking proof of his disinterestedness, by constantly refusing to solicit for him any place or situation under government. This son ultimately settled in the country, on an estate near Beauvoir. Turgot gave one of Quesnay's grandsons a place in the administration; and another entered the army, and acted as captain of infantry at the battle of Jemmappes.

Few men have been more esteemed by their friends than Quesnay, or more ready to do all in their power to advance their interests. Mercier de la Rivière, the author of the

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[1] We are at a loss to conjecture the grounds on which Mr Chalmers has affirmed (Biographical Dictionary, vol. xxv. art. *Quesnay*) that the "economists abused their influence by circulating democratical principles." It would be quite as correct to say that Locke and his followers abused their influence by circulating *despotical* principles.

[2] *Journal de Madame du Hausset*, in the *Mélanges*, &c. p. 277. A striking instance of the confidence placed by the most opposite parties in Quesnay is given in the second volume of Marmontel's Memoirs.

Quesne || Quevedo.

work *Sur l'Ordre Naturel et Essentiel des Sociétés Politiques*, seems to have occupied the chief place in his esteem, and was looked upon by him as the only person in France qualified to conduct the administration of the finances. He was also much attached to the Marquis de Mirabeau, Turgot, Dupont, the Abbé Baudeau, St Péravy, and other leading economists, who willingly acknowledged him for their master, and enthusiastically exerted themselves to defend and to propagate his doctrines. "The economists were in reality, and not merely in appearance, a sect of philosophers.

> Secta fuit servare modum, finemque tueri
> Naturamque sequi, patriæque impendere vitam,
> Nec sibi sed toti genitum se credere mundo.

They acted from an honest zeal for the truth, and not from fashion, eccentric tastes, or the love of singularity; their sole object was to enlighten and improve mankind; and to them, amongst political inquirers, belongs the rare praise of having first pointed out the natural order of things, or the observed course of nature in the conduct of the world, as the example and guide of human policy." (c. c.)

QUESNE, Marquis du Quesne, admiral of the naval forces of France, and one of the greatest men of the seventeenth century, was born in Normandy in the year 1610. He contributed to the defeat of the naval power of Spain at Gattari; he was dangerously wounded before Barcelona in 1642, and on other occasions; and having entered into the service of the Swedes, he became vice-admiral, and entirely defeated the Danes, killing their admiral, and taking his ship. He was recalled into France in 1647, and commanded the squadron sent to Naples. The naval affairs of France being much decayed, he fitted out divers ships for the relief of the royal army that blockaded Bordeaux, which was the principal cause of the surrender of the town. He was very fortunate in the wars of Sicily, where he defeated the Dutch thrice, and De Ruyter was killed. He also obliged the Algerines to sue in a very humble manner for peace from France. In short, Asia, Africa, and Europe, felt the effects of his valour. He was a Protestant; yet the king bestowed on him the land of Bouchet, and, to immortalize his memory, gave it the name of that great man. He died in 1688.

QUESTOR, or Quæstor, in Roman antiquity, an officer who had the management of the public treasure. The questorship was the first office which any person could hold in the commonwealth, and have a right to sit in the senate. At first there were only two; but afterwards two more were created to take care of the payment of the armies abroad, and to sell the plunder, for which purpose they generally accompanied the consuls in their expeditions. On this account the latter were called *peregrini*, as the former were called *urbani*. The number of questors was afterwards greatly increased. They had the keeping of the decrees of the senate; and hence came the two offices of *quæstor principis*, or *augusti*, sometimes called *candidatus principis*, whose office resembled in most respects that of our secretaries of state, and the *quæstor palatii*, answering in a great measure to our lord-chancellor.

QUEUE, in *Heraldry*, signifies the tail of a beast. Thus, if a lion be borne with a forked tail, he is blazoned double-queued.

QUEVEDO de Villegas, Francisco, a celebrated Spanish poet, born at Madrid in the year 1570. He was descended from a noble family, and was made a knight of St James; but he was thrown into prison by order of Count Olivarez, whose administration he satirized in his verses, and was not set at liberty until after that minister's disgrace. Quevedo wrote some heroic, lyric, and facetious poems. He also composed several treatises on religious subjects, and translated some authors into Spanish. He died in 1644. The best known of his works are, 1. The Spanish Parnassus; 2. The Adventurer Buscon; 3. Visions of Hell Reformed. Quevedo was one of the greatest scholars and most eminent poets of his time. His youth was spent in the service of his country in Italy, where he distinguished himself by the utmost sagacity and prudence. His moral discourses prove the soundness of his doctrine and his religious sentiments, whilst the correctness of his literary pieces display his accurate judgment and refined taste. His great knowledge of Hebrew is apparent from the report of the historian Mariana to the king, requesting that Quevedo might revise the new edition of the Bible of Arias Montanus. His translations of Epictetus and Phocylides, with his imitations of Anacreon and other Greek authors, show how well he was versed in that language; that he was a Latin scholar, his constant correspondence, from the age of twenty, with Lipsius, Chifflet, and Scioppius, sufficiently illustrates. As a poet, he excelled both in the serious and burlesque style, and was singularly happy in that particular turn which we have since admired in Butler and Swift.

Quiberon || Quietists.

QUIBERON, a market-town of France, in the department of Morbihan, and arrondissement of L'Orient. It is situated on a peninsula, in a bay of the same name, and contains 1850 inhabitants. It is defended by the fort Penthièvre, on the same peninsula, and is remarkable for the unsuccessful attempt made in 1795, by a body of royalist emigrants, under the brave Sombreuil.

QUICK or Quickset *Hedge*, amongst gardeners, denotes all live hedges, of whatever sort of plants they are composed, to distinguish them from dead hedges; but in a more limited sense of the word, it is restricted to those planted with the hawthorn, under which name the young plants or sets are sold by the nursery-gardeners, who raise them for sale.

QUICKLIME, a general name for all calcareous substances when deprived of their fixed air; such as chalk, limestone, and oyster-shells, calcined.

QUICKSILVER, or Mercury, one of the metals, and so fusible that it cannot be reduced to a solid state but at a degree of cold equal to forty below zero of Fahrenheit's thermometer. See Chemistry.

QUICK-MATCH, amongst artillerymen, a kind of combustible preparation, formed of three cotton strands, drawn into length, and dipped in a boiling composition of white-wine vinegar, saltpetre, and mealed powder. After this immersion it is taken out hot, and laid in a trough, where some mealed powder, moistened with spirits of wine, is thoroughly incorporated into the twists of the cotton, by rolling it about therein. Thus prepared, they are taken out separately, and drawn through mealed powder; then hung upon a line and dried, after which they are fit for immediate service.

QUID pro Quo, in *Law*, denotes the giving one thing of value for another; or the mutual consideration and performance of both parties to a contract.

Quid *pro Quo*, or Qui *pro Quo*, is also used in physic to express a mistake in the physician's bill, where *quid* is written for *quo*, that is, one thing for another; or of the apothecary in reading *quid* for *quo*, and giving the patient the wrong medicine. Hence the term is in general extended to all blunders or mistakes committed in medicine, either in the prescription, the preparation, or the application of remedies.

QUIDDITY, Quidditas, a barbarous term, used in the schools for *essence*. The name is derived from this, that it is by the essence of a thing that it is a *tale quid*, such a *quid*, or thing, and not another. Hence what is essential to a thing is said to be *quiddative*.

QUIETISTS, a religious sect, famous towards the close of the seventeenth century. They were so called from a kind of absolute rest and inaction which they supposed the

Quietists.

soul to be in when arrived at that state of perfection they called the *unitive life;* in which state they imagined the soul wholly employed in contemplating its God, to whose influence it was entirely submissive, so that he could turn and drive it whither and how he would. In this state, the soul no longer needs prayers, hymns, and the like, being laid, as it were, in the bosom and between the arms of its God, in whom it is in a manner swallowed up.

Molinos, a Spanish priest, is the reputed author of Quietism, though the Illuminati in Spain had certainly taught something like it before. The sentiments of Molinos were contained in a book which he published at Rome in the year 1681, under the title of the Spiritual Guide. For this he was cast into prison in 1685; but he afterwards publicly renounced the errors of which he was accused. This solemn recantation, however, proved unavailing, inasmuch as it was followed by a sentence of perpetual imprisonment, and he died in prison in the year 1696. Molinos had numerous disciples in Italy, Spain, France, and the Netherlands. One of the principal patrons and propagators of Quietism in France was Marie Bouvières de la Mothe Guyon, a woman of fashion, remarkable for goodness of heart and regularity of manners, but of an unsettled temper, and subject to be drawn away by the seduction of a warm and unbridled fancy. She derived all ideas of religion from the feelings of her own heart, and described its nature to others as she felt it herself. Accordingly her religious sentiments made a great noise in the year 1687; and, after accurate investigation, they were declared unsound by several men of eminent piety and learning, and professedly confuted in the year 1697, by the celebrated Bossuet. Hence arose a controversy of greater moment between the prelate last mentioned, and Fénélon, archbishop of Cambray, who seemed disposed to favour the system of Madame Guyon, and who, in 1697, published a book containing several of her tenets. Fénélon's book was, by means of Bossuet, condemned in the year 1699, by Innocent XII.; and the sentence of condemnation was read by Fénélon himself at Cambray, where he exhorted the people to respect and obey the papal decree.

A sect similar to this had appeared at Mount Athos in Thessaly, near the end of the fourteenth century; it was called *Hesychasts*, meaning the same with Quietists. They were a branch of the mystics, or those more perfect monks who, by long and intense contemplation, endeavoured to arrive at a tranquillity of mind free from every degree of tumult and perturbation. In conformity to an ancient opinion of their principal doctors, who thought there was a celestial light concealed in the deepest retirements of the mind, they used to sit every day, during a certain space of time, in a solitary corner, with their eyes eagerly and immoveably fixed upon the middle regions of the belly, or navel; and boasted, that whilst they remained in this posture, they found, in effect, a divine light beaming forth from their soul, which diffused through their hearts inexpressible sensations of pleasure and delight. To such as inquired what kind of light this was, they replied, by way of illustration, that it was the glory of God, the same celestial radiance that surrounded Christ during his transfiguration on the Mount. Barlaam, a monk of Calabria, from whom the Barlaamites derived their denomination, styled the monks who adhered to this institution Massalians and Euchites; and he gave them also the new name of *Umbilicani*. Gregory Palamas, archbishop of Thessalonica, defended their cause against Barlaam, who was condemned in a council held at Constantinople in the year 1341.

The Mahommedans seem to be no strangers to Quietism. They expound a passage in the seventeenth chapter of the Koran, "O thou soul which art at rest, return unto the Lord," of a soul which, having, by pursuing the concatenation of natural causes, raised itself to the knowledge of that being which produced them and exists of necessity, rests fully contented, and acquiesces in the knowledge of Him, and in the contemplation of his perfection.

Quillet ‖ Quiloa.

QUILLET, Claude, an eminent Latin poet of the seventeenth century, was born at Chinon, in Touraine, and practised physic there with reputation; but having declared against the pretended possession of the nuns of Loudun, in a manuscript treatise, the original of which was deposited in the library of the Sorbonne, he was obliged to retire into Italy, where he became secretary to the Marshal d'Estrées, the French ambassador at Rome. In 1655, Quillet having published in Holland a Latin poem, entitled *Callipædia*, under the name of *Galvidius Lætus*, he there inserted some verses against the Cardinal Mazarin and his family; but that cardinal making him some gentle reproaches, he retrenched what related to the cardinal in another edition, and dedicated it to him, Mazarin having, before it was printed, given him an abbey. He died in 1661, aged fifty-nine, after having given Ménage all his writings, and five hundred crowns to pay the expense of printing them; but the Abbé took the money and papers, and published none of them. His *Callipædia* has been translated into English verse.

QUILLOTA, a province of the republic of Chili, in South America, about twenty-five leagues in length from north to south, and nearly twenty-one leagues in breadth from east to west. It is rich in metallic ores, and also very productive in an agricultural point of view. All kinds of grain and vines are here cultivated, and the hemp and honey of the province are much esteemed. The capital, St Martin de la Coucha, or Quillota, is built upon a fertile valley on the banks of the Acoucagua, one of the rivers which descend from the western declivities of the Andes, and flow into the ocean. It contains about 8000 inhabitants, and is situated about one hundred miles north-west from Santiago. The population of the whole province is estimated at between forty and fifty thousand.

QUILOA is the name of a kingdom of Eastern Africa, situated to the north of Mozambique. The island of Quiloa, which appears to constitute the principal part of the sovereignty, lies opposite a peninsula formed by two great rivers, the most important of which is called Coavo. This situation confers on it the accommodation of three safe and spacious ports. It is accessible at all times, and forms the mart for the trade of slaves of the whole coast of Zanguebar; but the king is compelled to yield half of the profits to the powerful schiek of the island of Zanzibar, who appoints a vizier to look after his rights. Indeed the negro monarch enjoys little more than a nominal sovereignty; for the viceroy of Zanzibar, generally a Moor, keeps him in a state of tutelage, and rules supremely in his name. The continent produces a species of teak-wood, as durable as that from Surat, of the greatest beauty, and well adapted for ship-building. The sugar-cane, cotton-tree, and indigo, are indigenous to the soil. The gigantic baobab, the tamarind, the cedar, the tree which yields gum-copal, and the coffee-plant of Madagascar, are also found here. Game, and herds of every species of wild animal, particularly the wild ox, as well as river and sea-fish, are abundant. Lions, panthers, elephants, and other formidable tenants of the forest or the desert, often visit the banks of the two rivers for the purpose of quenching their thirst. These banks are ornamented by large trees, interspersed with villages subject to the authority of the king of Quiloa. Fruits and vegetables are scarce, and millet forms the principal food of the natives. The women cultivate millet and potatoes from custom and necessity; and some also make mats and coarse stuffs for their own use. Hunting or fishing forms the chief employment of the male part of the population. The chief town of the island, which bears the same name, was the capital of Eastern Africa, when first visited by the Portuguese in

Quimper ‖ Quin.

the beginning of the sixteenth century. They succeeded in establishing themselves, but were at last driven out by the Imam of Muscat. There are but few traces of its ancient splendour and power now remaining. Long. 39. 47. E. Lat. 8. 41. S.

QUIMPER, an arrondissement of the department of Finisterre, in France. It is six hundred and forty-one square miles in extent, is composed of nine cantons, divided into sixty-five communes, and contains 82,800 inhabitants. The capital is the city of the same name. It is on the acclivity of a hill, about ten miles from the sea, at the junction of the rivers Odet and Benaud. The harbour is accessible for vessels of two hundred tons burden, and in the road of Benaudet the largest ship can ride in security. It is the see of a bishop, and contains a cathedral, four other churches, 1010 houses, with 6750 inhabitants, who carry on a considerable coasting trade and some fisheries. Near this place an attempt was made to land a body of royalists under Puysaye during the revolution, but it totally failed, and the greater part of them were executed. This was the birthplace of the celebrated Hardouin. Long. 4. 12. 30. W. Lat. 47. 58. 24. N.

QUIMPERLE, an arrondissement of the department of Finisterre, in France, extending over three hundred and sixteen square miles. It is divided into five cantons and twenty communes, and contains 37,200 inhabitants. The capital is the city of the same name. It stands in a rich valley, where the rivers Isolle and Elle unite their waters, and form a small and shallow harbour. It is an ill-built place, and much scattered, but contains 800 houses and 5800 inhabitants. Long. 3. 39. W. Lat. 47. 51. 53. N.

QUIN, James, a celebrated performer on the English stage, was born at London in 1693. He was intended for the bar; but preferring Shakspeare to the statutes at large, he, on the death of his father, when it became necessary for him to do something for himself, appeared on the stage at Drury Lane. In 1720 he first displayed his comic powers in the character of Falstaff, and soon afterwards appeared to as great advantage in Sir John Brute; but it was upon Booth's quitting the stage that Quin showed to most advantage, in the part of Cato. He continued a favourite performer until the year 1748, when, on some disgust between him and Mr Rich the manager, he retired to Bath, and only came up annually to act for the benefit of his friend Ryan, until the loss of two front teeth spoiled his utterance for the stage. Whilst Mr Quin continued upon the stage, he constantly kept company with the greatest geniuses of the age. He was well known to Pope and Swift; and the Earl of Chesterfield frequently invited him to his table; but there was none for whom he entertained a higher esteem than for the poet Thomson, the author of the Seasons, to whom he made himself known by an act of generosity that does the greatest honour to his character. Mr Quin's judgment in the English language recommended him to Frederick prince of Wales, who appointed him to instruct his children in speaking and reading with a graceful propriety; and Quin being informed of the elegant manner in which his majesty delivered his first speech from the throne, he cried out in a kind of ecstasy, "Ay, I taught the boy to speak." Nor did his majesty forget his old tutor; for, soon after his accession to the throne, he gave orders, without any application being made to him, that a pension should be paid to Mr Quin during his life. Mr Quin, indeed, was not in absolute need of this royal benefaction; for, as he was never married, and had none but distant relations, he sunk L.2000, which was half his fortune, in an annuity, for which he obtained L.200 a year, and, with about L.2000 more in the funds, lived in a decent manner during the latter part of his life at Bath, whence he carried on a regular correspondence with Mr Garrick, and generally paid a visit to his friends in the metropolis once a year, when he constantly passed a week or two at Mr Garrick's villa at Hampton. He died of a fever in 1766.

Quinarius ‖ Quinqueremis.

QUINARIUS was a small Roman coin, equal to half the denarius, and consequently worth about threepence three farthings of our money. It was called *quinarius*, because it contained the value of five asses, in the same manner as the denarius was named from its containing ten.

QUINAUT, Philip, a celebrated French poet, born of a good family, at Paris, in 1635. He cultivated poetry from his infancy, and sixteen dramatic pieces of his were acted between the years 1653 and 1666. In the mean time, Quinaut was not so much devoted to poetry but that he applied himself to the study of the law, and made his fortune by marrying the widow of a rich merchant to whom he had been useful in his profession. Quinaut afterwards turned his attention to the composing of operas, which were set to music by Lully, who was charmed with a poet whose verses were not too nervous to yield to the capricious airs of music. He died in 1688, after having for many years enjoyed a handsome pension from Louis XIV.; and he was extremely penitent in his last illness for all those of his compositions which tended to inspire love and pleasure.

QUINCUNX, in Roman antiquity, any thing that consists of five twelfths of another, but particularly of the *as*.

Quincunx *Order*, in *Gardening*, is a plantation of trees, disposed originally in a square consisting of five trees, one at each corner, and a fifth in the middle; which disposition, repeated again and again, forms a regular grove, wood, or wilderness.

QUINDECAGON, in *Geometry*, a plain figure with fifteen sides and fifteen angles.

QUINDECEMVIRI, in Roman antiquity, a college of fourteen magistrates, whose business it was to preside over the sacrifices. They were also the interpreters of the Sybil's books, which, however, they never consulted except by an express order of the senate.

QUINHONE, an excellent harbour in Cochin-China, where vessels are sheltered from every wind. The entrance is narrow, and it is only at high water that vessels of great burden can enter. Lat. 13. 52. N.

QUINQUAGENARIUS, in Roman antiquity, an officer who had the command of fifty men.

QUINQUAGESIMA Sunday, Shrove Sunday, so called as being about the fiftieth day after Easter.

QUINQUATRIA, or Quinquatrus, was a festival celebrated at Rome in honour of Minerva, and which began on the 18th of March, or, as others will have it, on the 19th, and lasted five days. On the first day they offered sacrifices and oblations without the effusion of blood; the second, third, and fourth, were spent in shows of gladiators; and on the fifth day they went in procession through the city. Scholars had a vacation during the solemnity, and at this time presented their masters with a gift or fee, called *Minerval*. Boys and girls used to pray to the goddess Minerva for wisdom and learning, of which she had the patronage. Plays were acted, and disputations held, at this feast, on subjects of polite literature. The quinquatria were so called, because they lasted for five days. There seems to be a strong resemblance between this festival and the panathenæa of the Greeks.

QUINQUENNALIS, in Roman antiquity, a magistrate in the colonies and municipal cities of that empire, who had much the same office as the ædile at Rome.

QUINQUEREMIS, in the naval architecture of the ancients, is a name given to a galley which had five rows of oars. They in general divided their vessels into *monocrota* and *polycrota*. The former had only one tier of rowers; the latter had several tiers of them, from two or three, up to twenty, thirty, or even forty; for in the time of Philopater we have an account of such a vessel, which required no less than four thousand men to row it.

Quinqueviri ‖ Quintilian.

Meibomius has diminished the imaginary improbability of there ever having been such a vessel, by reducing the enormous height supposed to be necessary for such a number of rows of oars, and men to work them, and finding a better way of placing the men than others had thought of. The quinqueremes of the ancients had 420 men in each, 300 of whom were rowers, and the rest soldiers. The Roman fleet at Messina consisted of 330 of these ships; and the Carthaginian, at Lilybœum, of 350 of the same size. Each vessel was 150 feet in length. Thus, 130,000 men were contained in the one, and 150,000 in the other, with the apparatus and provisions necessary for such expeditions as they were intended for. This gives so grand an idea of the ancient naval armaments, that some have questioned the truth of the statement; but we find it related by Polybius, an historian too authentic to be questioned, and who expresses his wonder at the circumstance whilst he relates it.

QUINQUEVIRI, in Roman antiquity, an order of five priests, peculiarly appointed for the sacrifices to the dead, or celebrating the rites of Erebus.

QUINTESSENCE, in *Chemistry*, a preparation consisting of the essential oil of some vegetable substance, mixed and incorporated with spirit of wine.

QUINTESSENCE, in *Alchemy*, is a mysterious term, signifying the fifth or last and highest essence of power in a natural body. Or, when divested of its alchemical signification, and employed to express something that is intelligible, the word denotes merely the highest state of purification in which any body can be exhibited.

QUINTAL, the weight of 100 lbs. in most countries, but in England it is the cwt. or 112 lbs. Quintal was formerly used for a weight of lead, iron, or other common metal, usually equal to 100 lbs. at six scores to the hundred.

QUINTETTO (English, *Quintet*), in music, a composition for five voices, or for five instruments, each of which is *obbligato*. The remarks that have been made upon the construction of the quartetto apply generally to that of the quintetto. Amongst the finest instrumental quintettos are those of Boccherini, Mozart, Beethoven, and Onslow. The best that have been composed for wind-instruments only, are A. Reicha's for flute, oboe, clarinet, horn, and bassoon.

QUINTILE, in *Astronomy*, an aspect of the planets when they are seventy-two degrees distant from one another, or a fifth part of a zodiac.

QUINTILIAN (MARCUS FABIUS QUINTILIANUS), a celebrated rhetorician and critic, who flourished in the first century of the Christian era. His life, written by an unknown author, is prefixed to several editions of his works. From it we learn that he was born at Rome, though under what consuls, or in what reign, is unknown; and that no credit is due to the tradition which makes him a native of Calagurris or Calahorra, in Spain, since he is not amongst the number of the Iberians whom Martial has celebrated. In fact, that poet names him apart from any others, and, in the homage which he pays, clearly intimates that he was a Roman.

Quintiliane vagæ moderator summe juventæ,
Gloria Romanæ, Quintiliane, togæ.

Quintilian calls himself the son of an advocate, and informs us besides that, in his youth, he was acquainted with Domitius Afer and Seneca, who both perished under Nero. Seneca speaks of Quintilian, a declaimer, the grandfather of him who so long taught rhetoric at Rome. Domitian intrusted the instruction of his grand-nephews to Quintilian; and another pupil of his, C. Cælius, became the best orator of the time. Having married a lady of a noble family, Quintilian had the grief to lose her, as well as one of the sons she had brought him; an affliction which he experienced soon after he had composed his book on the causes of the corruption of eloquence. He then wrote his books of rhetoric, but whilst engaged in the composition of the work, he lost his other son. His daughter, whom he had by a second wife, married Novius Celer, a man of distinction. The anonymous author concludes by stating that he does not know in what year Quintilian died. Quintilian.

According to the calculations of Dodwell, he must have been born in the year 42 of our era, and must have died under Hadrian, some time between the years 117 and 138. Those who hold him to have been a Spaniard, say that he was brought to Rome by Galba; and the same thing is stated in the chronicle of Eusebius. But Quintilian himself assures us that at Rome he was acquainted with Domitius Afer; and the death of this orator took place in the year 55 of our era. Dodwell, therefore, conjectures that in 61 Quintilian followed Galba into Spain, where he taught rhetoric pleaded causes, and in the year 68 returned to Rome with the same emperor. From this time until the year 88 he gave lessons in rhetoric, a public provision having been attached to this function by Galba, according to Dodwell; by Domitian, according to the chronicle of Eusebius; by Vespasian, according to Suetonius. At the same time, Quintilian shone at the bar, where his pleadings attracted so much notice that they were written out and sold. He enjoyed an honourable degree of credit, and, according to Juvenal, a considerable fortune; which, however, accords but indifferently with the present that he received from Pliny the younger, as a portion to his daughter. It is possible, indeed, that Pliny, in mentioning this fact, may be speaking of a different Quintilian; but it may be observed, that no other rhetorician of the name is known at the time here referred to. Dodwell supposes that the author of the *Institutiones Oratoriæ* was consul in the year 117, and others that he held this dignity either before or after this date. Some words of Ausonius and Juvenal have led to this conclusion, but neither of these writers has expressly mentioned the fact.

If it be difficult, however, to ascertain the details of his life, it is easy enough to recognise the eminent merit of his work, forming, as it does, the most complete course of rhetoric which the ancients have left us. Of this work Gibert and Laharpe have both given very ample analyses. The first book treats of the education of the orator; the second, of the art of oratory in general; the following, of invention, arrangement, elocution, memory, and action; the twelfth and last, of the manners and character of the orator, or rather of the advocate. The author loves to descend to details of all sorts, sometimes even to those relating to grammar; and, besides, he intermingles with his precepts so many observations, and, above all, so many facts, that his work is indispensable for acquiring a competent knowledge of the literary history of antiquity. The gravest fault which has yet been detected in the work, consists in the praises lavished upon Domitian; a deformity which, in the eyes of Bayle, Dodwell, and even Gibert, is alike disgusting and inexcusable. In a literary point of view, it may be observed that Quintilian, in citing and contradicting the rhetoricians who have preceded him, particularly Aristotle, does not always seize the true import of their words, and consequently ascribes to them doctrines they never maintained, and precepts they never inculcated. In other respects, if his work be long, it is also full; and all the obscurity we find in it is reduced to some details of which all trace was effaced soon after his time, and which he does not explain sufficiently for us, because they were familiar to his Roman readers. The enumeration which he has made of more than a hundred figures is of more importance than is commonly supposed to the theory of language and of thought. Nevertheless, Rollin took the trouble of abridging this rhetoric, in order to render it more accessible and more useful to youth, and retrenched nearly a fourth of the

Quintilian. original work; but, in our opinion, it would be much better to leave classical books as they are, especially when they inspire only pure tastes and virtuous sentiments.

In point of style, the work of Quintilian has no pretensions to equal or be compared with the treatises of Cicero on the art of oratory; but it is nevertheless written with much sagacity and elegance. Severe censors have thought that the preface of the sixth book savours of declamation. The author therein deplores the loss of his second son, which he had just sustained, and retraces the recollections of another son, and of a young wife, whom death had also removed. But, to say the truth, the expression of his grief is not so simple or so natural as could be wished; and, in the concluding part, we perceive almost as much of the rhetorician as of the father. This preface, however, is read with interest, and has no resemblance to the Declamations, of which a long and useless collection has been published under the name of Quintilian. They are distinguished into great and small; the former, nineteen in number, and the latter, a hundred and forty-five, being all that remain of three hundred and eighty-eight. Philelphus, Vives, and especially Erasmus, have shown that the nineteen great declamations could not have proceeded from the pen of Quintilian. In fact, there are manuscripts which assign them to M. Florus; and a text of Trebellius Pollio would authorize the belief that they were the work of Postumus the younger, one of the thirty tyrants: "Postumus...ita in declamationibus disertus, ut ejus controversiæ Quintiliano dicantur insertæ." Notwithstanding the authority of several manuscripts, and that of Lactantius, Ennodius, and Vincent de Beauvais, we cannot discover in them a trace of Quintilian. The difference is too sensible, even in the diction; he never could have written *dilectio*, *discretio*, *impœnitens*, *lenocinamentum*, and other expressions belonging to a class which he must have strongly condemned. As to the hundred and forty-five smaller declamations, if they were really his, they might have been extracts from his pleadings, collected by the tachygraphers. Perhaps they belonged to his father or his grandfather, or some other person of the same name; perhaps they were the productions of different authors and different ages, which the inequalities observed in them seem almost to indicate. But the circumstance which has most puzzled the learned, is the distinction of these pieces into two kinds; the *coloratæ*, and the *tractatæ*. May not this second qualification have been applied to those the subjects of which had really been treated, and the first to such as invested imaginary themes with all the colours of rhetorical embellishment? or, if another supposition be admissible, may not the *tractatæ* have been the simple expositions of causes, whilst the *coloratæ* were such as admitted of embellishment?

A production, however, which would do much more honour to Quintilian, were he really the author of it, is the dialogue *De Causis corruptæ Eloquentiæ*. He had certainly composed a treatise bearing this title; for, in the preface to the sixth book of his Institutions, he expressly mentions the fact; but on referring to the same treatise at the end of the eighth, he says that he has there spoken more at large of tropes, and particularly of hyperbole, which is not in accordance with the dialogue, the interlocutors in which are Aper, Maternus, Julius Secundus, and Vipsanius Messala. Pierre Pithou, Colomies, Dodwell, and many other learned men, have preferred ascribing it to Tacitus; and one of the grounds on which this opinion rests is the character of the political observations scattered throughout this little work. Besides, in several manuscripts, Tacitus is distinctly pointed out as its author. But it may not be the production either of the one or of the other. It has sometimes been ascribed to Suetonius, who, in his ascertained writings, has not the same force of thought and expression; and, in Fitzosborne's Letters, a very strong case has been made out in favour of Pliny the younger, although the latter has produced nothing under his own name which can be compared with this admirable dialogue. The treatise which Quintilian had composed on the causes of the corruption of eloquence, is not the only one of his productions which has perished. We have also lost his elementary rhetoric, in two books; and there remains no other authentic work of his but the Institutions, which had themselves nearly disappeared. This treatise existed in the middle ages, when it was known to and cited by Cassiodorus, Isidore of Seville, Loup de Ferrière, and Vincent de Beauvais. The manuscript which Petrarch consulted appears to have been in several respects defective; but that which, in 1419, Poggio discovered in the Abbey of Saint Gall, restored Quintilian to the light of day. Amongst the eminent services which Poggio rendered to letters, the discovery in question is not one of the least important. It is beyond a doubt, however, that the literati of the fifteenth century possessed at least defective copies of Quintilian; in proof of which we may refer to that letter of Leonardo Aretino, where he speaks with so much emphasis of the new apparition of this classic, at the same time declaring that he had long read and admired the half of the *Institutiones Oratoriæ*. These two manuscripts of Saint Gall and Leonardo Aretino were the sources of all those since made, as well as of the copies printed. Quintilians.

The first two editions of the Institutions of Quintilian appeared at Rome in 1470, the one printed by Udalricus Gallus, the other by Sweynheym and Pannartz, and both in folio. The fifteenth century produced ten others; and amongst the great number of the sixteenth may be distinguished, at Venice, those of the Alduses, 1514, in 4to, and at Paris, those of Vacosan, 1538, in folio; of Simon de Colines, 1541, in 4to; of Robert Etienne, 1542, in 4to; and of Mamert Patisson, 1580, in 8vo. This last was revised by Pierre Pithou, who added to it various readings, notes, and the hundred and forty-five small Declamations, of which there had yet appeared only a hundred and thirty-six. Schrevelius, and after him J. Frederic Gronovius, took charge of the edition which appeared at Leyden and Rotterdam, 1665, in 8vo, *cum notis variorum*. Here all the Declamations are joined to the Institutions, as in that of Strasbourg, which appeared in 1698, in 4to. In 1715, Rollin published his Quintilian abridged, Paris, *apud* the Etiennes, in two vols. 12mo. In the edition of 1720, which appeared at Leyden, in two vols. 4to, Peter Burmann profited by the labours of his predecessors on this author, including the *Annales Quintilianei* of Dodwell. Capronnier published at Paris, 1725, an edition in folio, with a selection of notes, and some critical observations, which offended Burmann, who replied, with all the intemperance of an enraged grammarian. But the edition of Mathias Gesner, Göttingen, 1738, in 4to, is more esteemed than either of the two preceding. Then followed that of Barbou, 1769, in 12mo; that of Deux-Ponts, 1784, in four vols. 4to; and that of Leipzig, 1719–1815, in four vols. 8vo, under the care of G. L. Spalding. The Institutions have been translated into the principal modern languages of Europe; into French, first by the Abbé de Pure, and second by Gédoyn; into Italian by Orazio Toscanella; into English, first by Guthrie, and next by Pastal; into German by Henke; into Spanish by two professors of the Charitable Schools in Madrid; and into Danish by Schlegel. Of the dialogue *De Causis corruptæ Eloquentiæ* there are also several translations, all of them French. The principal notices to be consulted respecting the life and works of Quintilian are, the *Annales Quintilianei* of Dodwell; Bayle's Dictionary; Fabricius, *Bibliotheca Latina;* Gibert, *Jugements des Savants sur les Rhéteurs;* and the *Lycée of Laharpe.* (A.)

QUINTILIANS, a sect of ancient heretics, who were so called from their prophetess Quintilia. In this sect the women

Quintin ‖ Quito.

were admitted to perform the sacerdotal and episcopal functions. They attributed extraordinary gifts to Eve for having first eaten of the tree of knowledge; and told great things of Mary the sister of Moses, as having been a prophetess; adding, that Philip the deacon had four daughters, who were all prophetesses, and were of their sect. In these assemblies it was usual to see the virgins entering in white robes, and personating prophetesses.

QUINTIN MATSYS, called also the *Farrier of Antwerp*, famous for being transformed, by the force of love, from a blacksmith to a painter. He had followed the trade of a blacksmith and farrier for nearly twenty years; when, falling in love with a painter's daughter who was very handsome, and disliked nothing but his trade, he quitted it, and betook himself to painting, in which he made very great progress. He was a diligent and careful imitator of ordinary life, and succeeded better in representing the defects than the beauties of nature. Some historical performances of this master deserve commendation, particularly a Descent from the Cross, in the cathedral at Antwerp; but his best known picture is that of the two Misers in the gallery at Windsor. He died in the year 1529.

QUINTUS CALABER, a Greek poet, who wrote a large supplement to Homer's Iliad, in fourteen books, in which a relation is given of the Trojan war from the death of Hector to the destruction of Troy. It is conjectured, from his style and manner, that he lived in the fifth century. Nothing certain can be collected either concerning his person or country. His poem was first made known by Cardinal Bessarion, who discovered it in St Nicholas's Church, near Otranto, in Calabria; and hence the author was named Quintus Calaber. It was first published at Venice by Aldus, but it is not stated in what year.

QUIRIA, a province of Immeritia, in Asia, which stretches along the shores of the Black Sea. It appears, from the ruins which are everywhere seen, to have been once a flourishing province.

QUIRINALIA, in *Antiquity*, a feast celebrated amongst the Romans in honour of Romulus.

QUIRITES, in Roman antiquity. In consequence of the agreement entered into by Romulus, and Tatius king of the Sabines, Rome was to retain its name, and the people were to be called *Quirites*, from Cures, the principal town of the Sabines. Dionysius of Halicarnassus says that each particular citizen was to be called *Romanus*, and the collective body *Quirites;* yet it appears by the ancient form of words used at funerals, *Ollus Quiris letho datus est*, that each private citizen was also called *Quiris*. The origin of the word *Quirites* has been much sought for; and the most probable account antiquity gives us of it is, that the word *Quir*, or *Quiris*, signified in the Sabine language a dart and a warlike deity armed with a dart. It is uncertain whether the god gave name to the dart, or the dart to the god.

QUIRK, in a general sense, denotes a subtile or artful distinction.

QUIRK, in building, is a piece of ground taken out of any ground-plot or floor.

QUITO, or EQUATOR, one of the three republics of South America which formerly constituted Colombia.[1] Its territory chiefly comprehends the ancient Spanish viceroyalty of Quito, extending from 2° of north to 6° of south latitude, and from 76° 30′ to 80° 40′ of west longitude. Its limits, however, in the direction of Brazil have not been definitely fixed, so that it may extend to the east considerably beyond 76° 30′. On the south it borders upon Peru and Brazil; the latter country forms its eastern boundary; on the north its limits are New Granada; and the whole of its territory on the west is washed by the Pacific Ocean. Quito is intersected by both chains of the Andes, and consequently presents great diversity of surface and of climate. These parallel mountain ranges, by uniting at Loxa, at Asuay, at Chisinche, and at Los Pastos, constitute what have been called mountain knots; and again opening up, they form the table-lands of Cuença, Hambato, and Quito. The circles of snow-covered mountains by which they are surrounded have a few passes opening to the west coast, or to the low plains on the east; but they are so rugged and wild as to be scarcely practicable. These elevated valleys, although immediately under the equator, yet, on account of their great height, enjoy a climate in the highest degree mild, and a temperature which seldom varies. They are extremely fruitful, and would be the most charming places in the world, were it not for the destructive earthquakes and volcanic eruptions which are not unfrequently experienced. There are in Quito sixteen volcanoes, which, although they discharge no lava, often throw up immense quantities of ashes, water, sludge, and fragments of rocks, along with columns of smoke and flame; and these eruptions are always accompanied by undulations of the earth. From the line to 1° 41′ of south latitude, stretching from north to south in the eastern portion of the valley of Quito, are Catocache, 15,402 feet; Cayambe Urcu, 18,330 feet; Antisana, 17,958 feet; Sinchulahua, 15,420 feet; and Cotopaxi, 17,712 feet above the level of the sea. In the west of the same valley are situated Pinchincha, 15,036 feet; Corazon, 14,820 feet; and Yliniza, 16,302 feet in height. In the second group, under 1° of south latitude, lying in a direction from north to south, are the volcanoes of Carguirazo, 14,700 feet, and Chimborazo, 20,158 feet, above the level of the Pacific. The latter mountain is usually covered with snow and ice, 4800 feet below the summit. In the vicinity of these, and about 16,000 feet in height, are the volcanoes of Tunguragua, Capac Urcu, and Sangai. But the most formidable of them all is Cotopaxi, the rocks thrown up by which would of themselves form a mountain chain of no inconsiderable size. Its eruptions have been numerous and destructive. In the year 1738 it projected upwards a column of fire nearly three thousand feet in height. In 1744 the subterranean sounds which it gave forth were heard at a distance of six hundred miles. One of the most frightful earthquakes which ever took place in this region, unhappily too celebrated for such visitations, was that of 1797, in which a tract of country one hundred and thirty miles in length by one hundred miles in breadth moved in undulatory billows like a stormy sea; many towns and villages were overthrown, and forty thousand human beings perished in a moment.

Quito.

The mountain chain of the Andes throws out a number of lateral ridges to the east, the country gradually subsiding into a vast plain extending along both sides of the Marañon, covered with majestic forests, and watered by innumerable streams. A number of rivers descend the western declivities of the Andes, and flow into the Pacific Ocean; others join the large streams of Cauca and Magdalena on the north; and the most important class consists of those that are tributaries of the Rio Negro and Marañon, which last river forms the boundary of the republic on the south. A portion of the territory of Quito on the east and north-east is watered by the Orinoco. Into this river fall the Atabapo and Guaviare, which at the same time form the line of separation between Cundinamarca and this republic. The Putumayo, Napo, Tigre, Pastaza, Marona, and Rio St Jago, which are large streams, besides many others of inferior note,

[1] In the year 1831, the republic then called Colombia separated into three independent states, the names of which are New Granada, Venezuela, and the Equator or Quito. The limits of each state have not been accurately settled, but an arrangement as to the amount of the national debt which was to fall to the share of each was completed at Bogota on the 23d of December 1834.

Quito. all of which flow from the north-west to the south-east, fall into the Amazons, and irrigate the flat eastern territory of Quito. The Andes of Quito also contain lakes of no inconsiderable dimensions, amongst which may be mentioned those of San Pablo and Cuicocha. In the level land on the east, many of the streams form lagunes during part of their course.

Many of the ravines, quebradas, and valleys of Quito have a very warm atmosphere; indeed, in some parts the heat is so oppressive as to render them uninhabitable. Other valleys which are more elevated are remarkably healthy, extremely productive, and delightful as places of residence. The valley of Quito is allowed to be the finest table-land in all America. It is enclosed, as we have said, between the two parallel ranges of the loftiest Andes, having an average breadth of thirty miles, but extending longitudinally much farther. In soil and climate it possesses every advantage. The climate is remarkably equable and agreeable; the indication of winter being the fall of rain, and the absence of rain marking the summer. The temperature is so benign that vegetation never ceases, the country all around the city of Quito exhibiting the beauty of perpetual spring. Hence it has been called *siempre verde* Quito, and also *eterna primavera*, both which epithets it may be said to deserve; for its native trees are all evergreens, and the fields on the slopes of the mountains never lose their verdure. The European sees with astonishment the plough and the sickle at once in equal activity; the green blade of grain and the yellow ear waving in the same breeze; one flower drooping, and its companion just beginning to "dedicate its beauty to the sun." In short, here the seasons of spring, summer, and autumn all go on at once, and the tints and varied beauties peculiar to each blend together in the same landscape. Mr Stevenson draws a glowing picture of these delightful valleys. They are, he says, "principally under cultivation, and bless the husbandman with a continued succession of crops; for the uninterrupted sameness of the climate in any spot is such as to preclude the plant as well as the fruit from being damaged by sudden changes in the temperature of the atmosphere, changes which are in other countries so detrimental to the health of the vegetable world. The fertility of some of these valleys exceeds all credibility, and the veracity of the description would be doubted, did not the knowledge of their localities, and the universal descriptions of the equability and benignity of these climates, insure the probability. One of these, called Pomasqui, is about five leagues from Quito, where sugar-cane arrives at a state of maturity in three years, and where many of the intertropical fruits attain the greatest perfection. This luxury is enhanced by the proximity of other situations possessing all the variety of climates known in the world. In the course of three hours a person may experience the rigidity of the poles, the oppressive heat of the equator, and all the intermediate temperatures."

An enumeration of all the different vegetable productions of this remarkable region is rendered unnecessary by the general view here given. It is sufficient to state, that grain, pulse, fruits, esculents, and horticultural vegetables are produced in the greatest abundance, and of an excellent quality, as well as all kinds of butcher-meat and poultry. The breeding of cattle and sheep, especially the latter, is extensively carried on in the high valleys. Excellent timber, fitted for ship or house building, and for every purpose of the cabinet-maker, abounds in many districts of the country. The soil is for the most part so productive of everything which usually occupies the attention of the husbandman and farmer, that butter, cheese, wax, mules, oxen, Peruvian bark, cacao, cotton, tobacco, grain, and other staples, form important exports. Sugar, wine, coffee, molasses, rum, and other spirits, are also amongst the products. Gold and silver are comprised in the metallic riches of the mountain territory. Some manufactures are carried on in different places. Quito.

According to the new constitution, this republic consists of the following provinces, viz. Quito, Chimborazo, Imbabura, Guayaquil, Monabi, Cuença, Loja del Archipelago, and Galopagos or Turtle Island.

Quito, the capital of the republic, is one of the finest and largest cities in the New World. It was founded in the year 1534, by Sebastian Benalcasar, with the dedicatory title of San Francisco, and in 1541 was created a city by Charles V. It stands in a ravine, at an elevation of more than 9000 feet above the level of the sea, in longitude 78° 45′ 17″ west from Greenwich, and in latitude 0° 13′ 17″ south. The mountain of Pinchincha lies on its west side, and on the east there is a range of hills called Chimbacalle. To the south is the plain of Turupampa or Turubamba, and to the north the plain of Anaquito, generally called Egido. The streets, which run north and south, stand on a pretty level plain, and are broad, handsome, and well paved; but those which cross them and climb the skirts of Pinchincha, descending on the east side of the city towards the small river of Machangara, are crooked and irregular. Quito has two universities, and it has always enjoyed celebrity for the great number of students by whom they are attended. There are a number of other seminaries of education in this city; indeed it is considered as comparatively a sort of American Athens. It is the seat of the congress, the president, and the highest offices of state, and enjoys a very extensive trade in cotton, silk, leather, gold, and silver. The commerce of Quito may be conveniently divided into two kinds, that of home and that of foreign manufactures. The former consists of cotton and woollen cloths, baizes, sugars, flannels, pouches, and other minor articles. The stock of foreign goods is composed of all kinds of European manufactures, including those of iron, steel, and some other raw materials. The articles most in demand are English broad cloths, kerseymeres, coloured broad flannels, calicoes, &c.; all kinds of hardware and cutlery, and foreign silk velvets, satins, as well as English ribbons and silks. The population amounts to about seventy-five thousand souls, and has been divided into three classes of nearly equal numbers; the whites, mestizos, and Indians. Here there are very few negroes, or descendants of that race, the Indians being generally engaged in domestic service.

Some remarkable monuments of the former sway of the Incas are found scattered at intervals in these delightful valleys. The ruins near Cayambe may be pronounced superb. Those of the palace of Callo present one of the most perfect examples of the ancient architecture of the Peruvians, which throughout the vast extent of the empire are marked by the most striking similarity. It forms a square, each side of which is one hundred feet in length. Four gates and eight interior apartments may be distinctly traced. The gates resemble those of the Egyptian temples; and the niches, of which there are eighteen in each division, are distributed in a very symmetrical manner. The remains of spacious porphyry palaces are found also at Autun, Canar, and some other places. The ruins of fortified places, called pucuras, still exist, and some of them are of considerable extent.

The province of Chimborazo, so called from the majestic mountain which overlooks its valleys, is distinguished for its breed of mules. Barley, potatoes, and maize are cultivated by the Indians in various parts, and some sugar-cane in the bottoms of the ravines. Riobamba, the capital of the province, was completely destroyed by the earthquake of 1797; and, with very few exceptions, the whole population, amounting to about twenty thousand, were buried under the ruins, or engulphed in the earth. Some idea of the terrible nature of the convulsion in this quarter may

Quito.

be gathered from the fact, that part of the ruins situated on the acclivities on each side of the valley where the new town now stands are pointed out as having once formed portions of one edifice, although now separated from each other a league and a half. The new town is built upon a sandy plain, much below the level of the surrounding elevated plains called *paranios*. Its climate is very agreeable, and adapted for producing all kinds of European fruits. Sheep-farming is extensively carried on, about four thousand quintals of sheep's wool being produced annually, and manufactured into different kinds of cloth. At Tescan, in the neighbourhood, there is a large sulphur-work; and here are seen part of those remains of hewn stones which run along the mountains almost to Cuzco, at a height of 13,800 feet above the level of the sea. This is called the road of the Incas, and, no doubt, was the means of communication between the two capitals in the regal days of the "Children of the Sun." Riobamba contains a population of 15,000; Ambato or Hambato, situated between Cotopaxi and Carguirazo, in a very fine region, contains 3000 inhabitants, who trade extensively in cochineal. This place also suffered severely in 1797. The other places in this province are, Alausi, situated in an elevated valley of the same name; Guano, which has a considerable trade with Popayan; Guarando, a dépôt for the trade between Quito and Guayaquil; and Pallactanga, where there are rich gold and silver mines.

The province of Imbabura contains many fine and fruitful valleys, in which there are extensive plantations of sugar-cane, from which the best sugar in the republic is manufactured. The wheat grown in this district is likewise of the finest quality. The capital, called Ibarra, is situated eighteen leagues to the northward of Quito. It is exceedingly well built, having fine streets and a spacious market-place; and it contains 12,000 inhabitants, who are employed to some extent in the weaving of cotton and woollens, and the manufacture of stockings and ponchos. To the south-west of Ibarra is the town of Otavalo, containing 20,000 inhabitants. Large quantities of cattle are bred in the neighbourhood, and cotton and woollens are manufactured here in the same manner as at Ibarra. Esmeraldas is situated near the mouth of a river of the same name, and is one of the few ports of the republic. The surrounding country is extremely fruitful; the sugar-cane grows to above ten feet in height, and the yam root sometimes weighs twenty pounds. Tacames is likewise a haven on the Pacific Ocean. But the great port of Quito is Guayaquil.

The remaining provinces may be briefly described. Loxa affords the finest cinchona, and was long supposed to be the only spot which produced in perfection that precious medicament. The town of Loxa is well built, and contains some fine churches, several well-organized seminaries of education, and a population of 10,000. The capital of Cuença, called St Anna de Cuença, is the seat of a bishop, and possesses a university, several schools and fine churches, with 20,000 inhabitants. The other towns in this quarter worthy of being mentioned are Azogues, where there are quicksilver mines; Zaruma, celebrated for its gold, silver, and lead mines; Beza, once populous, but now decayed to a mere village; and some other places, once of note, but now deserted wastes. The Gallopagos or Turtle Islands, stretching from 3° of south to 2° of north latitude, are celebrated for an uncommon species of land-turtle which they produce, weighing from fifty to three hundred pounds. The largest island is called Albemarle, and may be about sixty miles in length. It contains a good harbour. The whole group is said to be of volcanic origin.

Quit-rent ‖ Quotient.

The value of the trade of this republic will be seen from the following statement. In the year 1835 there entered inwards at the port of Guayaquil 123 vessels, of 21,430 tons burden in all, and with cargoes valued at L.221,680. The same number cleared outwards, and the value of their cargoes was L.210,429. The imports consist chiefly of British manufactures, flour, wine, and other necessaries; the exports, of cocoa, timber, and the other products of the country. The number of inhabitants is estimated at 550,000, including 300,000 Indians who dwell in the mountains; but some American accounts fix the population at only 481,966. With regard to the income and expenditure, little correct information is to be obtained. The former has been reckoned at 800,000 piastres, and the latter at about as much; but by the most recent intelligence the minister of finance estimates the outlay as low as 171,086 piastres. By the treaty regarding the national debt, already mentioned, the share which fell to Quito was 21½ per cent., or L.1,464,795 sterling.

On the first of May 1835, the congress of the nation, consisting of forty-five members, agreed to draw up a plan of a constitution for the country; but it does not appear that they have yet (1839) agreed about the details. (R. R. R.)

QUIT-RENT (*quietus redditus*, or quiet-rent) is a certain small rent payable by the tenants of manors, in token of subjection, and by which the tenant goes quiet and free. In ancient records it is called *white rent*, because paid in silver money, to distinguish it from corn-rent, or rent in kind.

QUOIN, or COIN, on board a ship, a wedge fastened on the deck close to the breech of the carriage of a gun, to keep it firm up to the ship's side. Cantic quoins are short, three-legged quoins put between casks to keep them steady.

QUOINS, in *Architecture*, denote the corners of brick or stone walls. The word is particularly used for the stones in the corners of brick buildings. When these stand out beyond the brick-work, their edges being chamfred off, they are called *rustic quoins*.

QUOTIDIAN, anything which happens every day.

QUORUM, a word frequently mentioned in our statutes, and in commissions of justices of the peace and others. It is so called from the words of the commission, *quorum* A B *unum esse volumus*. Where a commission is directed to seven persons, or to any three of them, whereof A B and C D are to be two, in this case they are said to be of the quorum, because the rest cannot proceed without them.

QUOTIENT, in *Arithmetic*, the number resulting from the division of a greater number by a smaller, and which shows how often the smaller is contained in the greater, or how often the divisor is contained in the dividend. The word is formed from the Latin *quoties*, which is as much as to say or ask, how often is such a number contained in such another. See ARITHMETIC.

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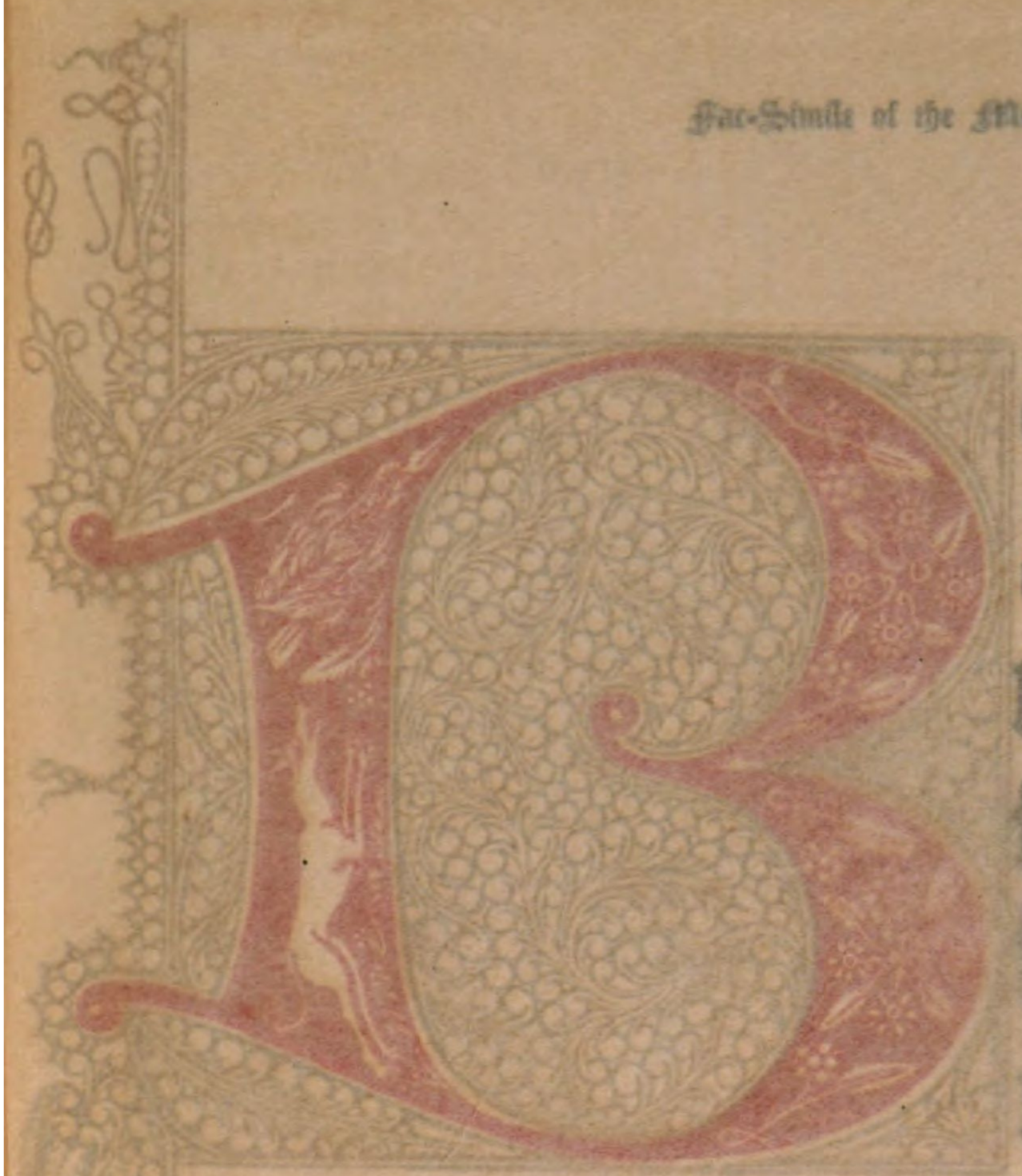
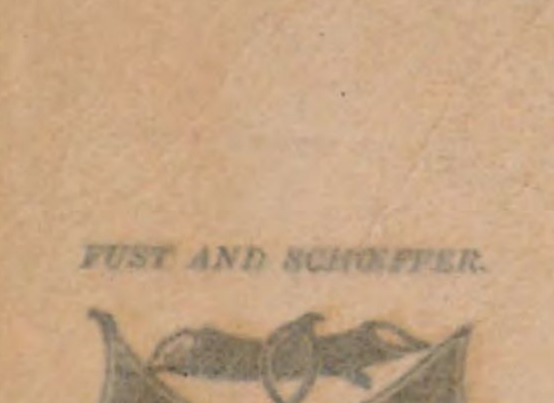
Fac-Simile of the Mentz Psalter, A



COLOPHONS.

FUST AND SCHOEFFER.



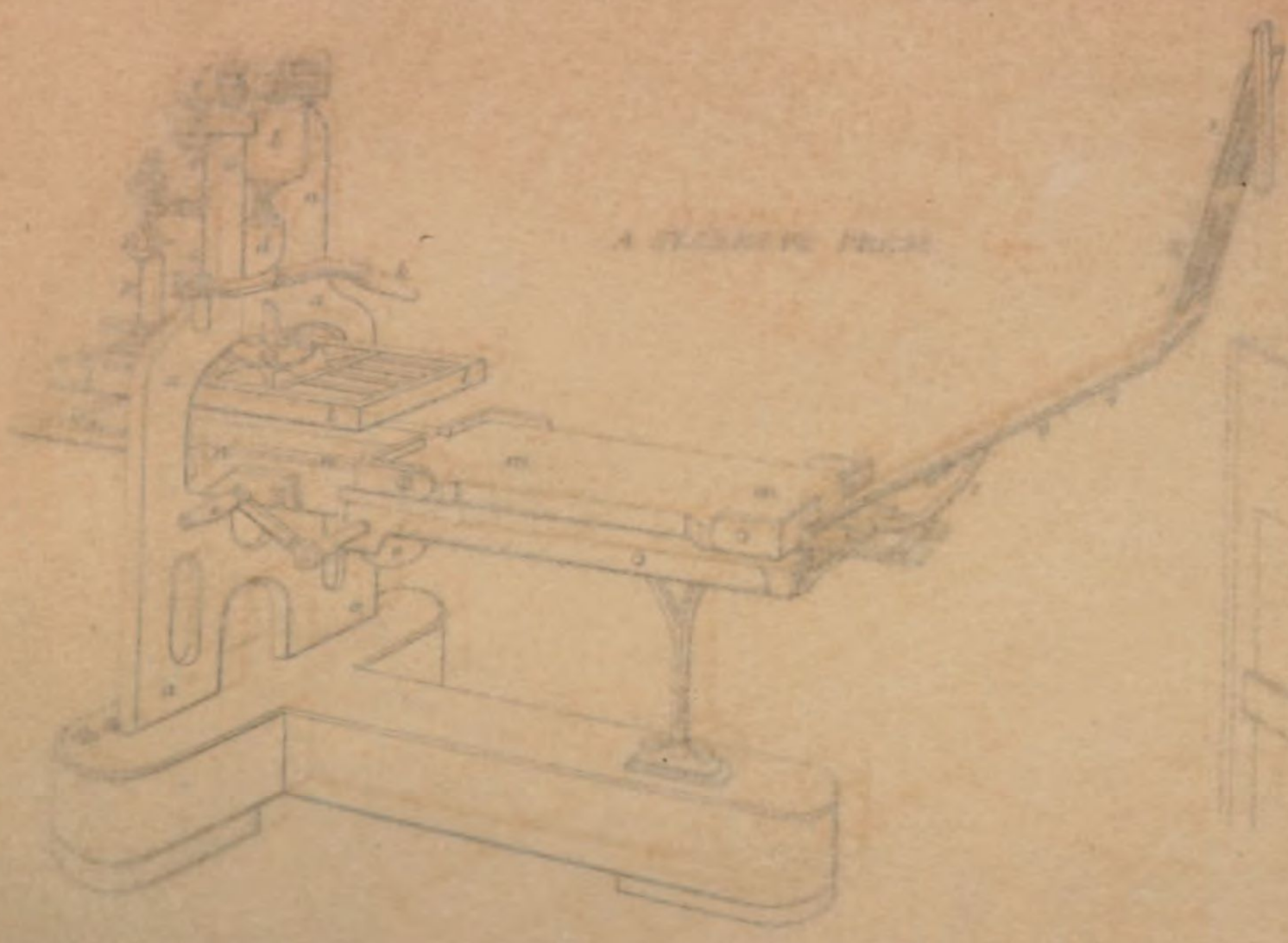
Fac-Simile of the Mentz Psalter, A.D. 1457.

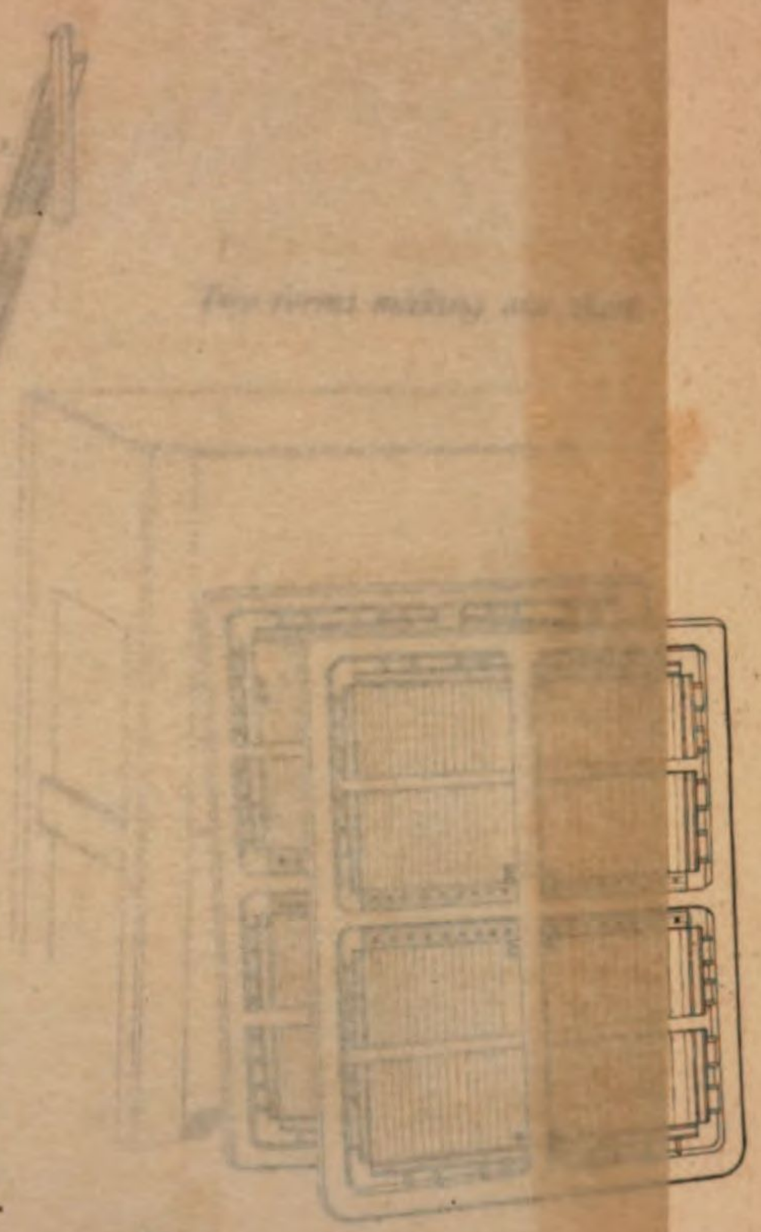
Beatus vir qui non
abijt in consilio impiorum
et in via peccatorum non
stetit: et in cathedra pesti-
lentie non sedit. Sed
in lege domini voluntas

COLOPHONS.

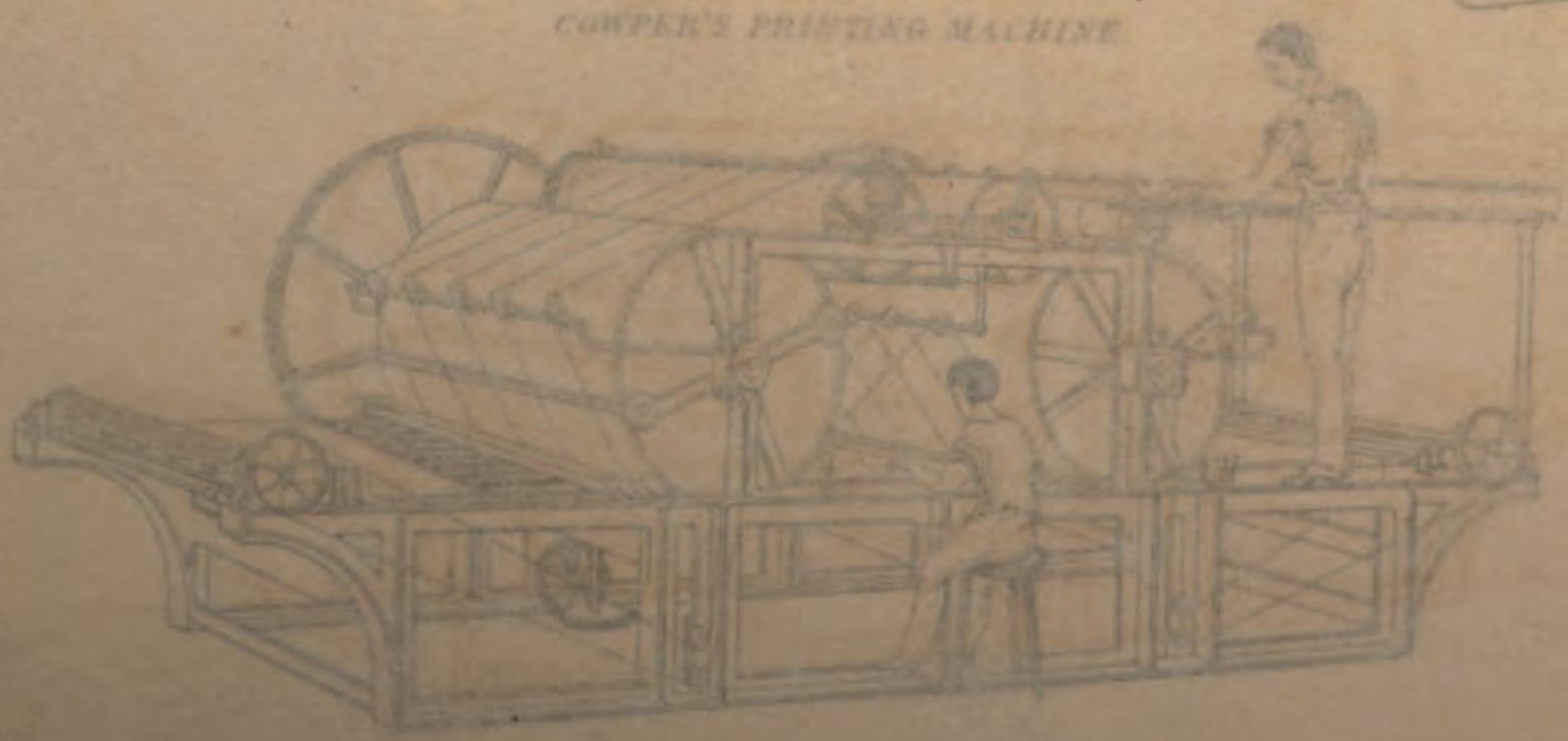
FUST AND SCHŒFFER.

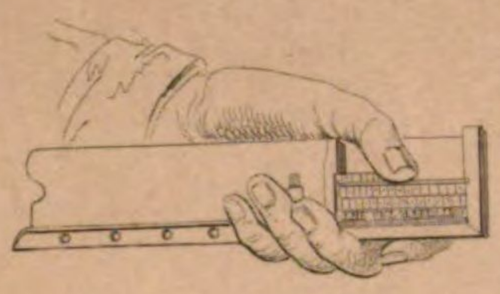
WILLIAM CAXTON.





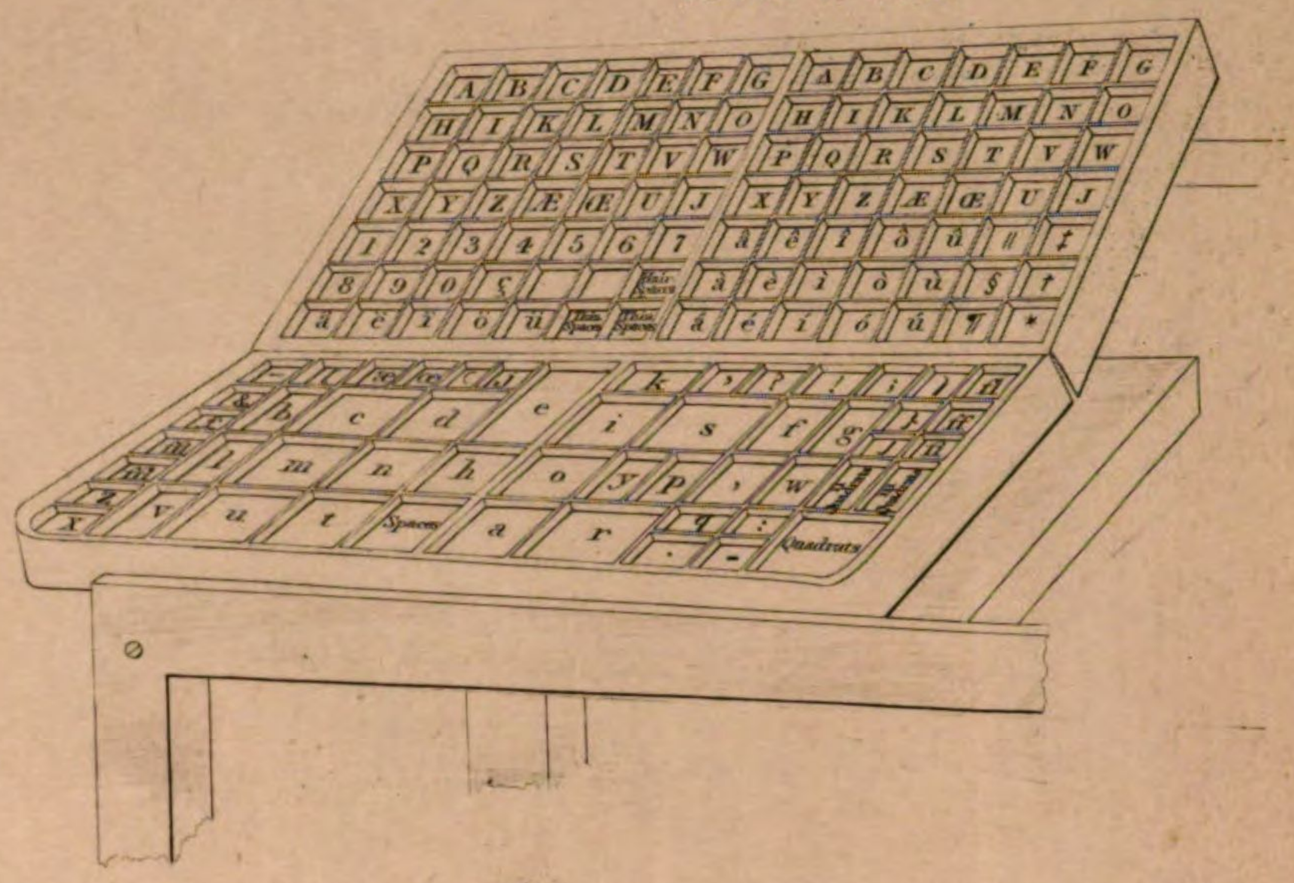
COWPER'S PRINTING MACHINE

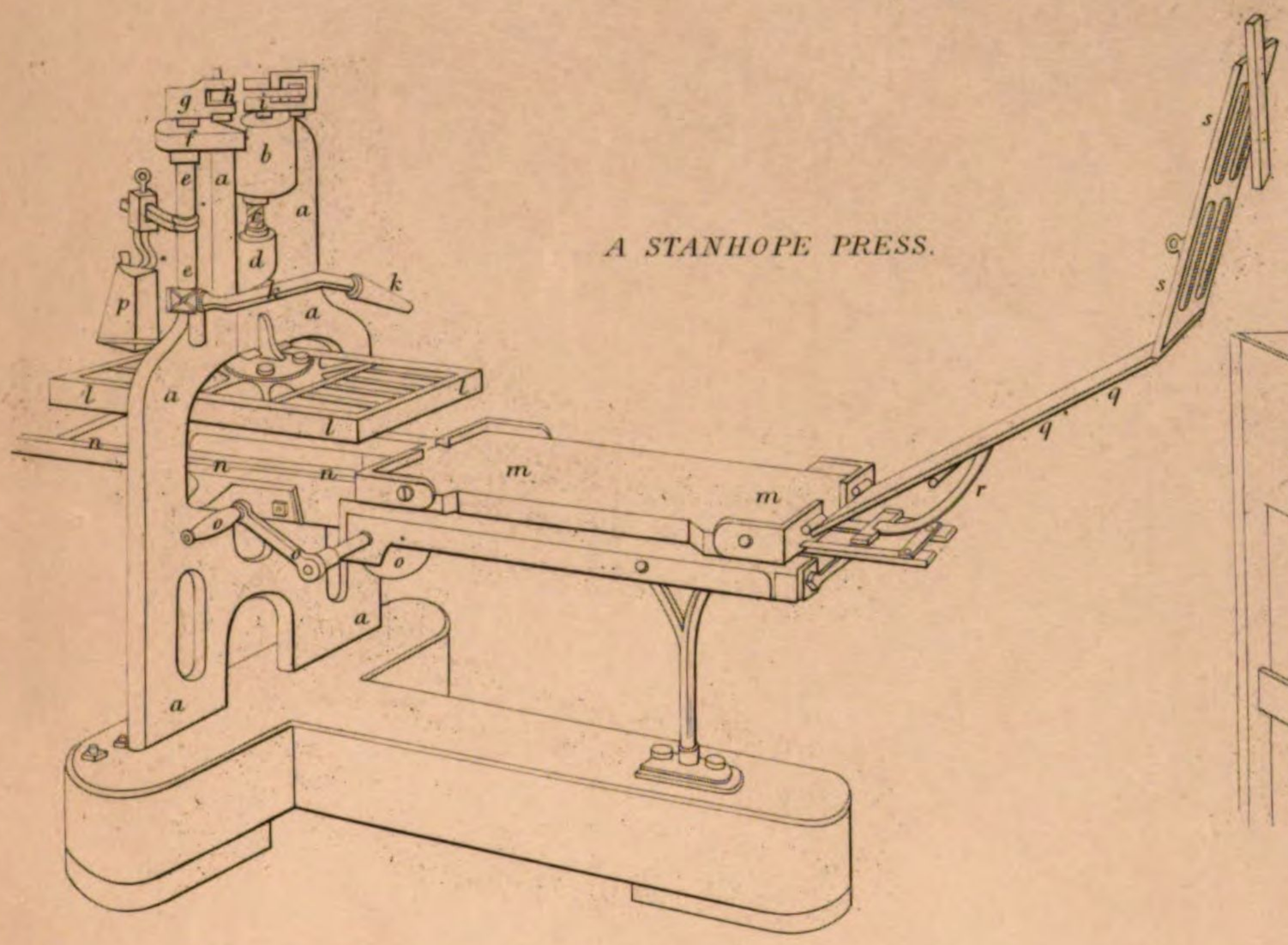




Composing-stick.

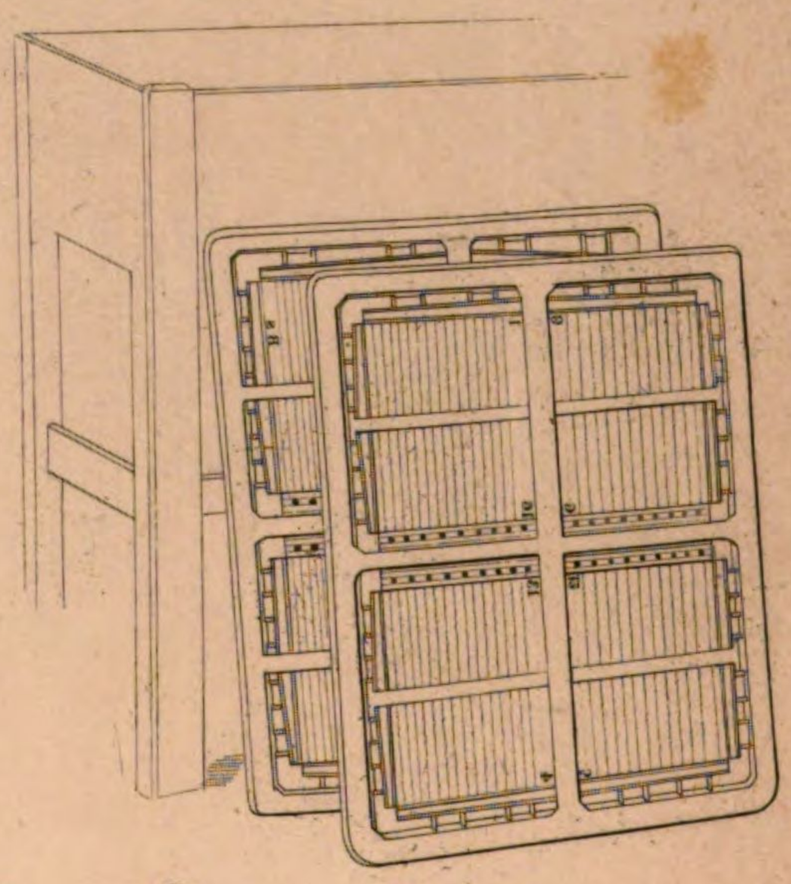
A Pair of Cases.





A STANHOPE PRESS.

Two forms making one sheet.



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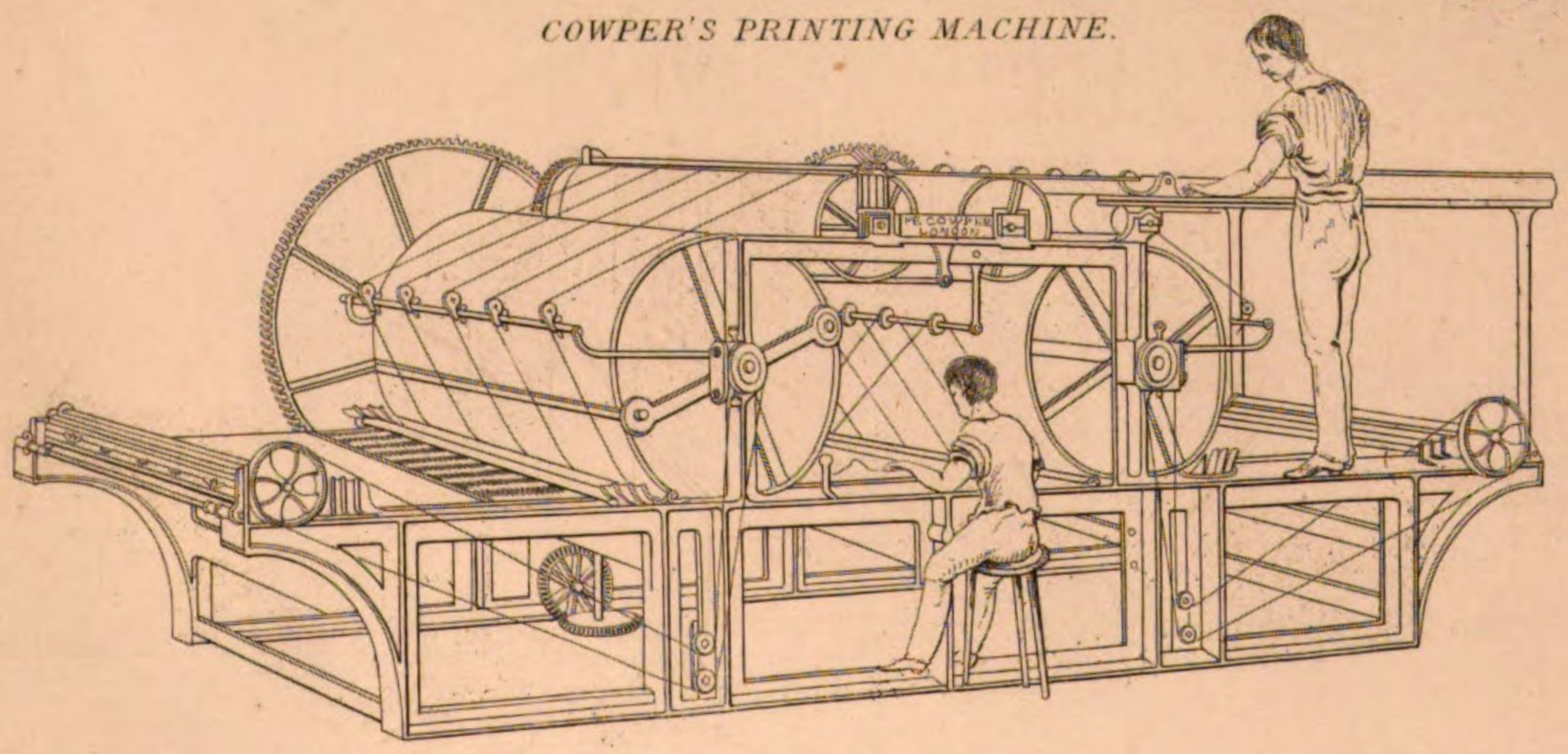
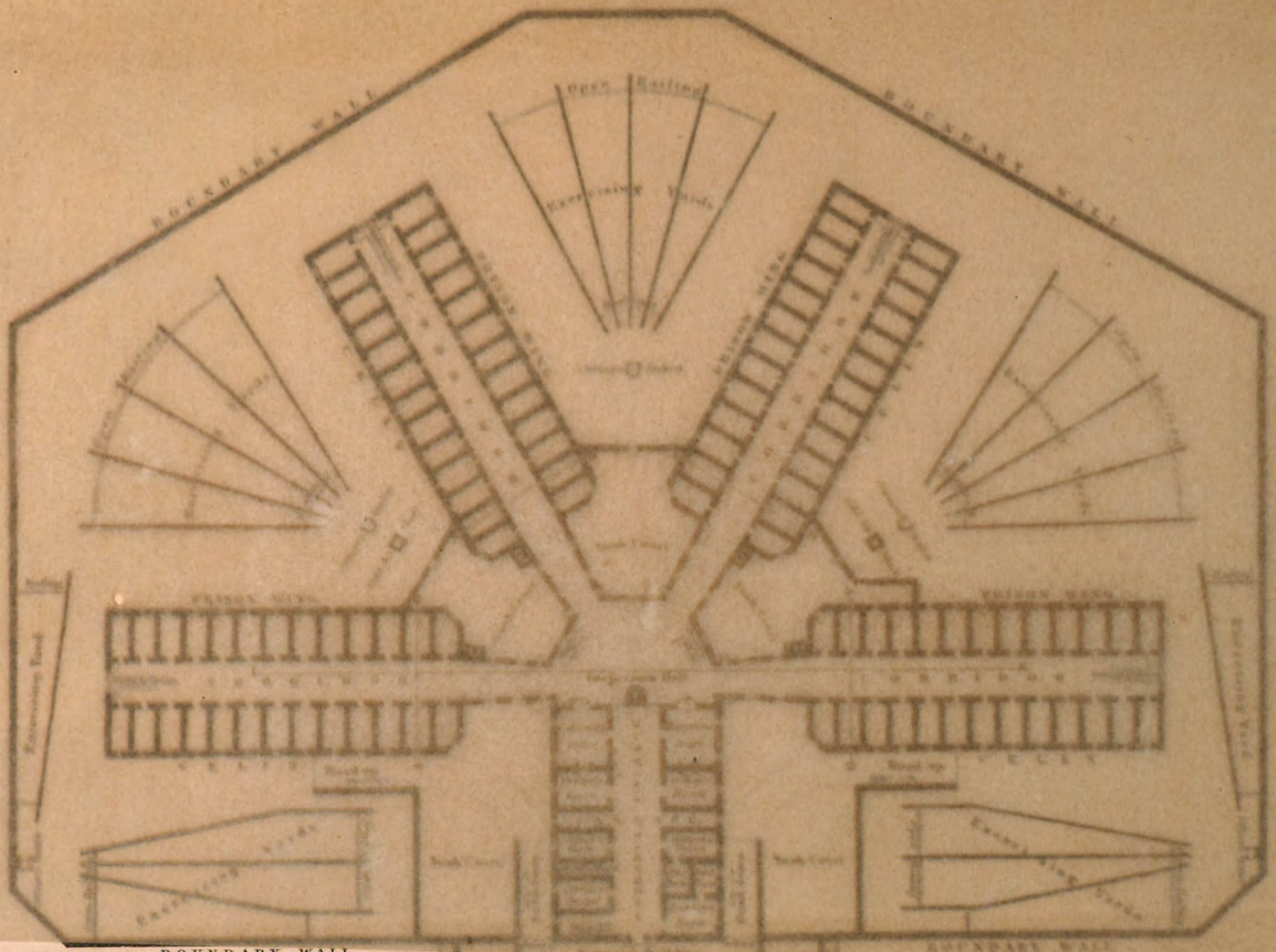
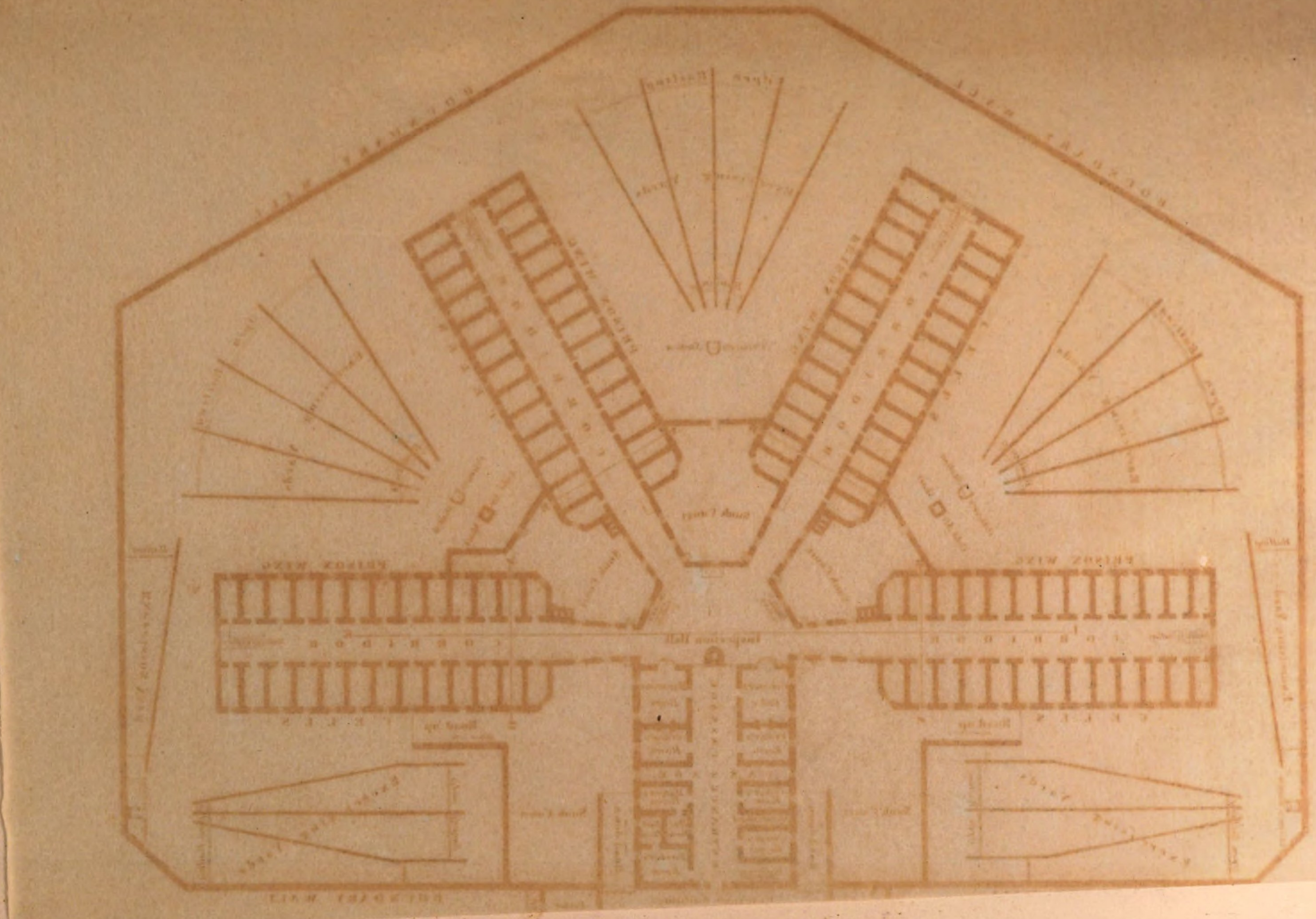
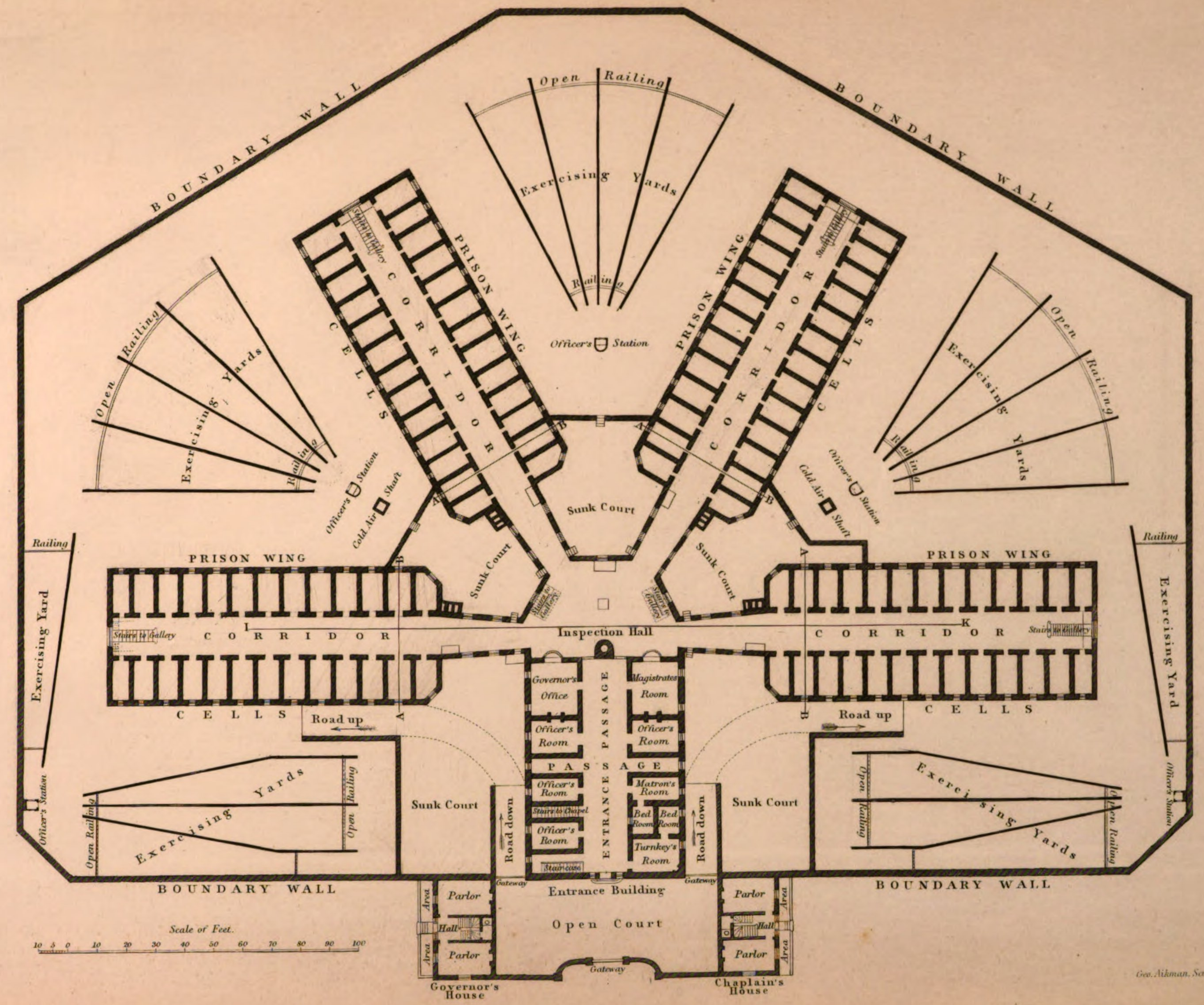


Geo. Aikman, Sculp.

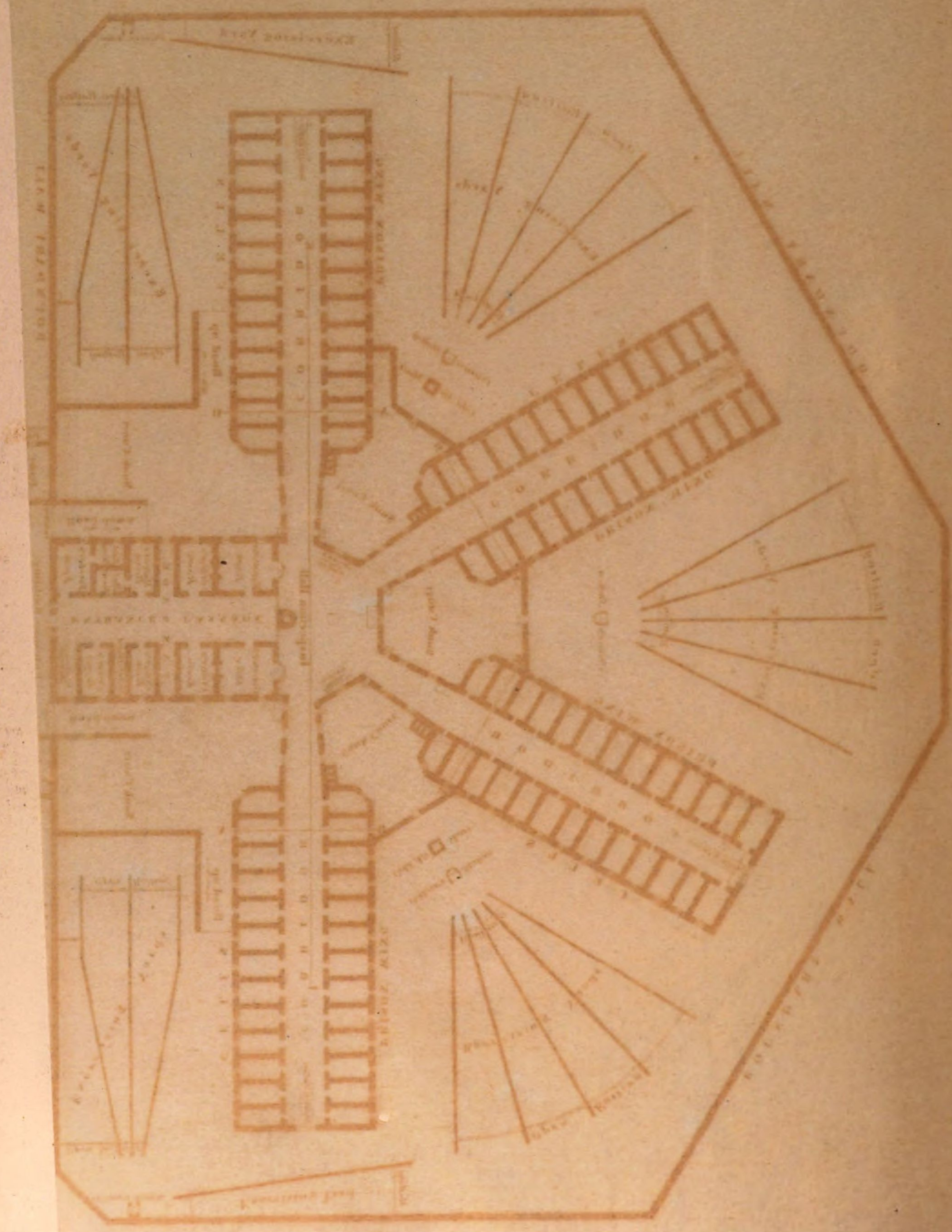


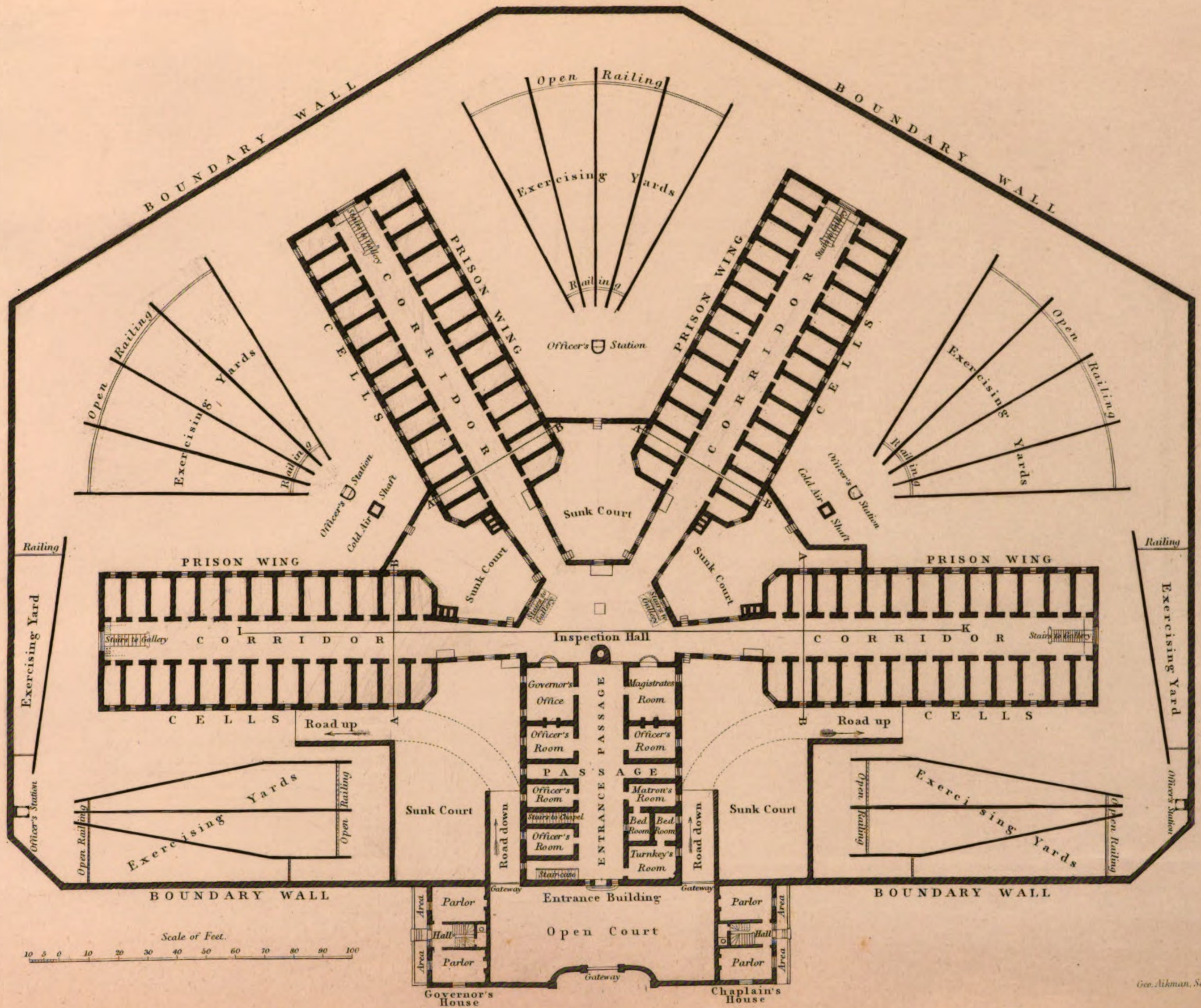
Geo. Aikman, Sculp!



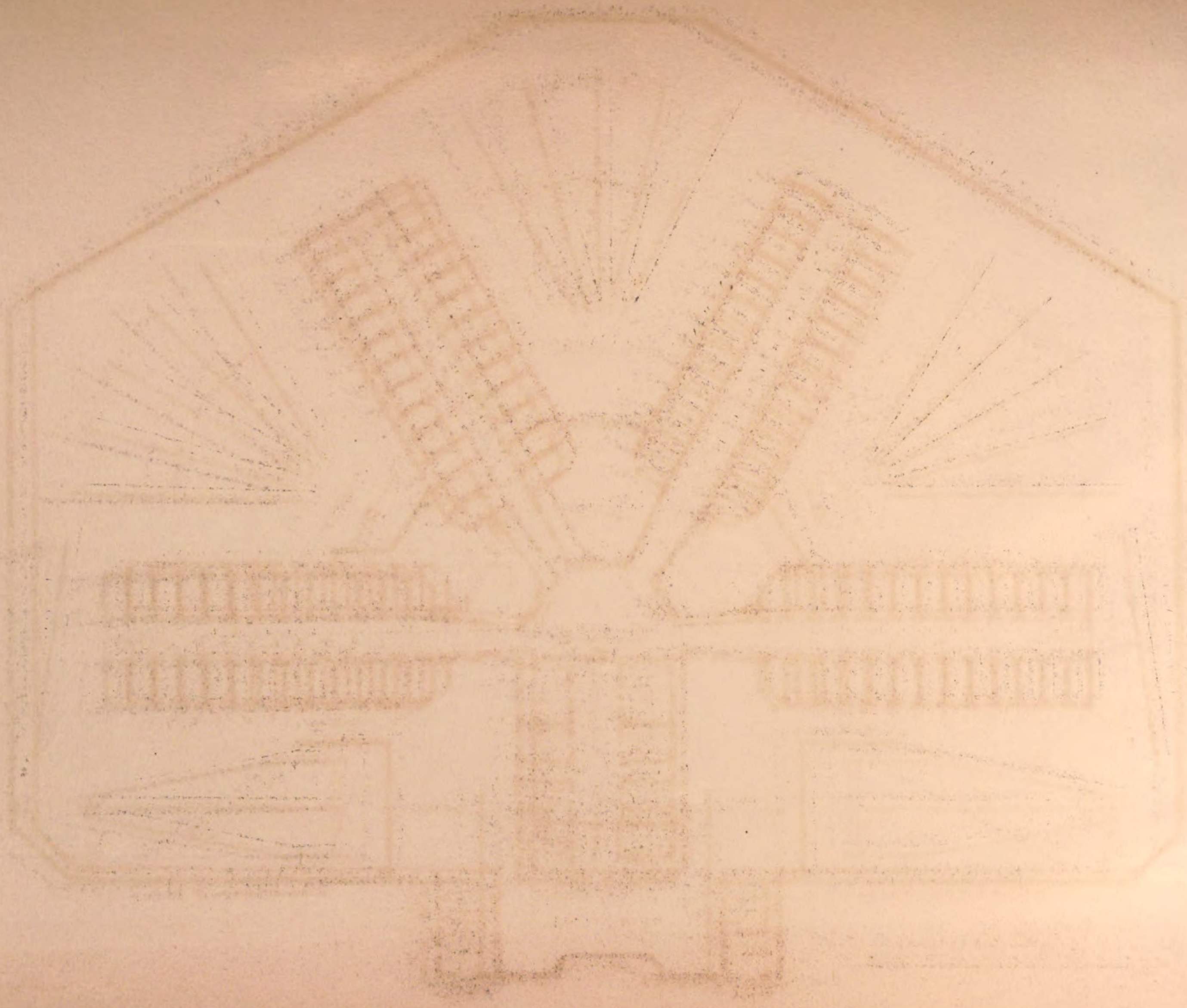


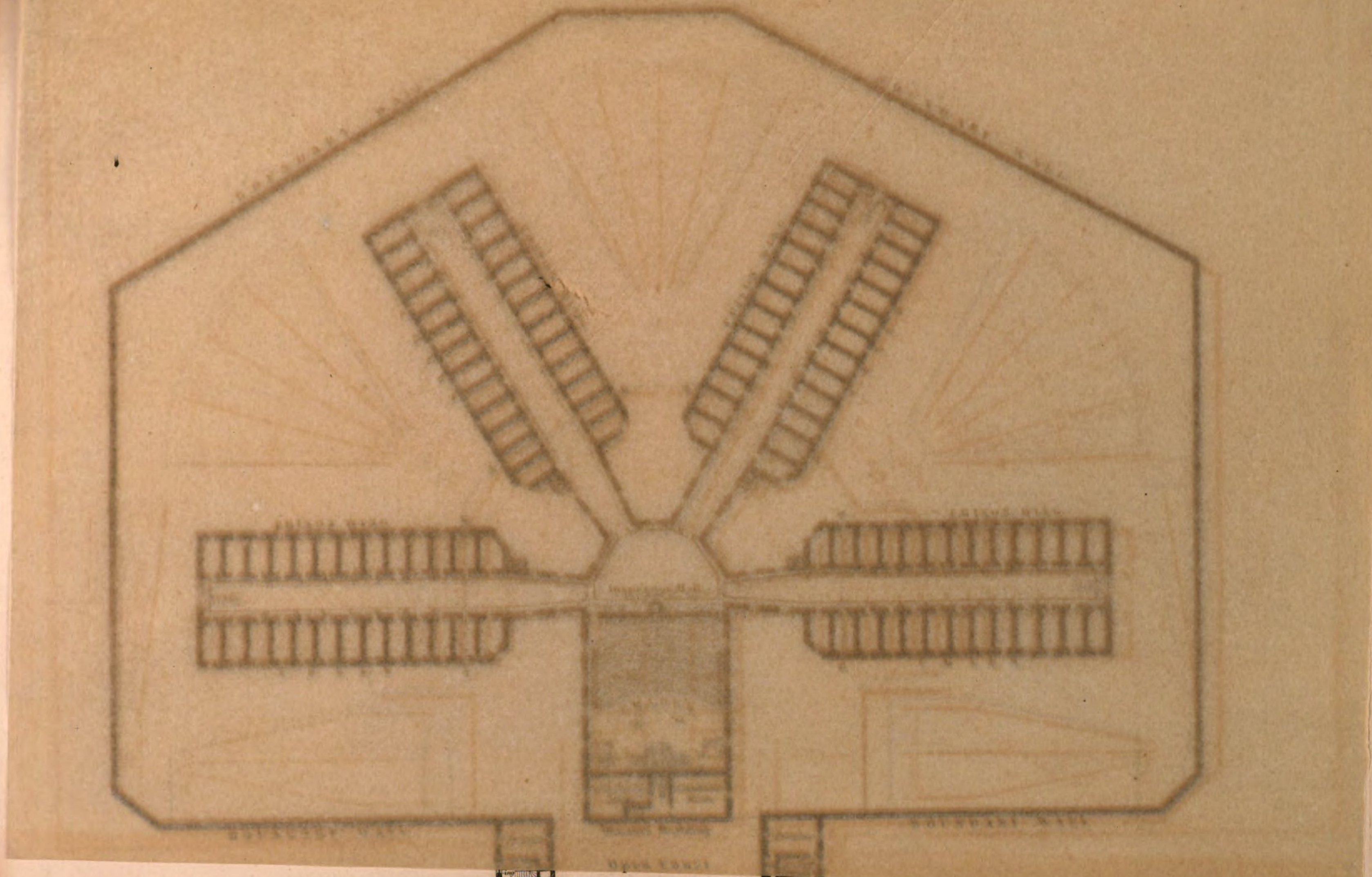
Geo. Aikman, Sculp!





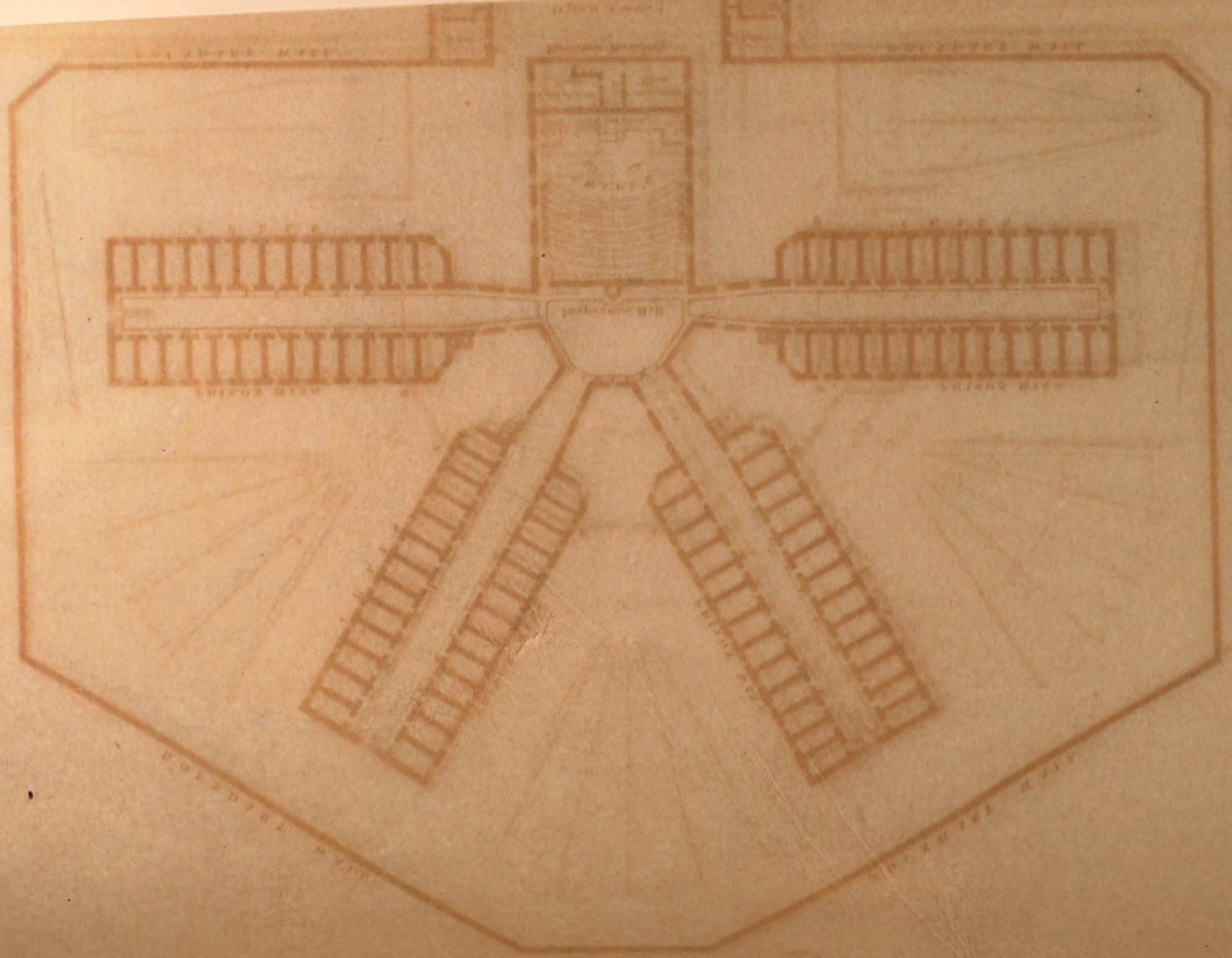
Geo. Aikman, Sculp!

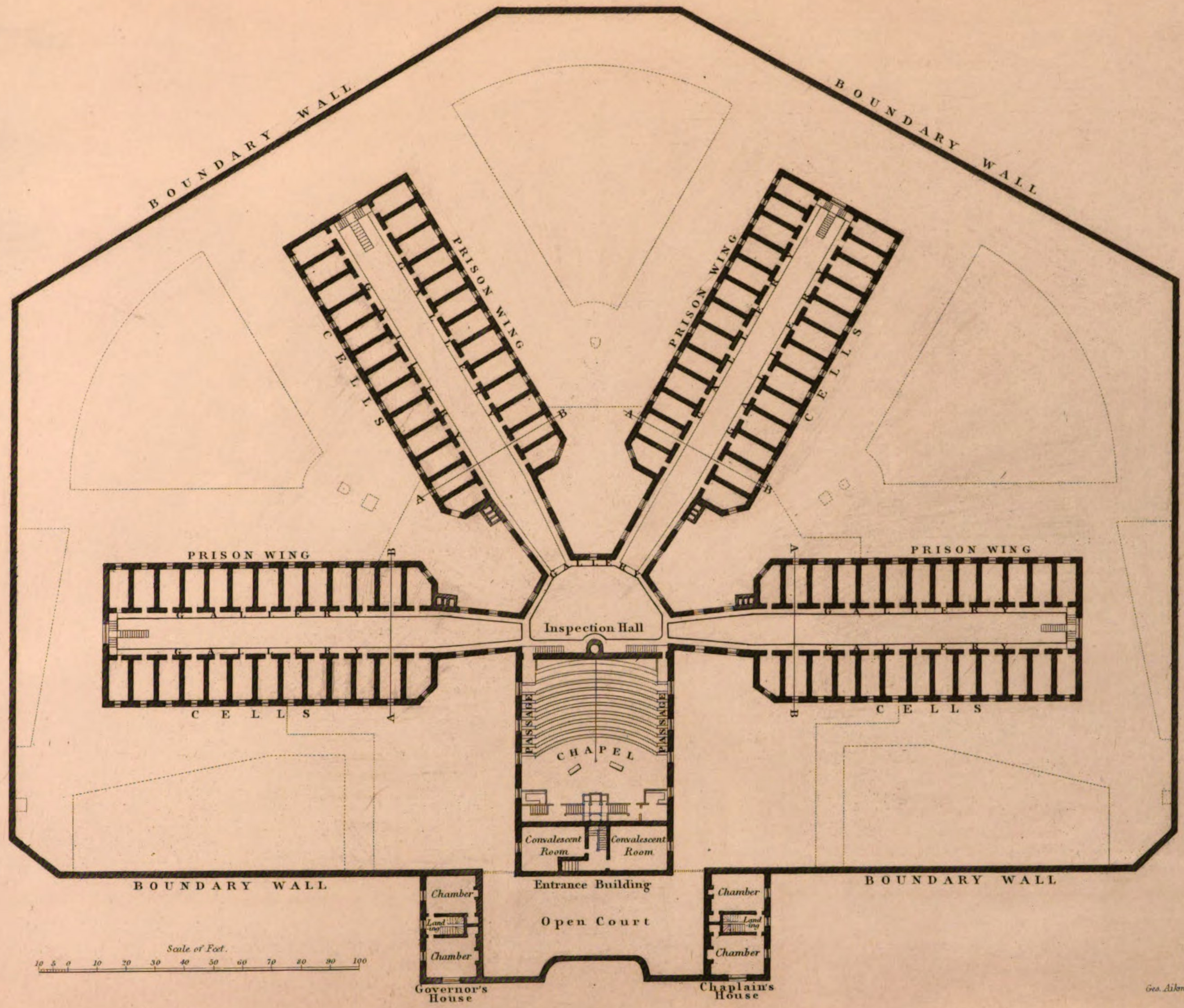




Scale of Feet.
10 5 0 10 20 30 40 50 60 70 80 90 100

Geo. Aikman. Sculpt





Geo. Aikman, Sculp.

10 11 12 13 14 15

55 54 53 52 51 50

DENMARK

SWEDEN

FUNEN

LANGELAND

LALAND

Falster

Moen

Bornholm

COPENHAGEN

BALTIC

Kroplitz Pulgarton Trener B. Hidden I. Dars G. Zingst I. Prerowdorp Binnen W. Schaard Prorer V. & B. Bergen Mandgut Griefwald I. STRALSUND Ribnitz Richtenberg Grimm Rostock Eldena Griefswald Wolgast Loitz Demmin Lassan Usedom Wollin Wiecknemunde Tonnin Treptow Voigtshagen Persante R. Rega R. Rutzow Colberg Robe Corlin Zarben Cammin Coselitz Gutzow Plate Naugarten Golnow Dabor Wangerit Falkenburg Dramburg Freyenwalde Nornburg Stargard Zachan Retz Werben Greifenhagen Arenswalde Fürstenau Zatten Bernstein Hochzeit Woldenburg Driesen Friedeburg Schneidemuhl Meseritz Tirschberg Bomst Zullichau Crossen Grünberg Unruhstadt Gunzendorf Sagan Glogau Sprottau Prinkmen Kotzenau Neudorf Bunzlau Goldberg Lowenberg Lahn Hohen Hirschberg Riesen Gebirge

Lubeck Wismar Rostock HAMBURG Schwerin MECKLENBURG Brandenburg Lubz Neustadt Meienburg Buttlitz Frevenstein Strelitz Strasburg Pasewalk Prenzlow Lychen Templin Grimmen Gartz Angermunde Schwedt Zeidenik Ferdinandsdorf Fallanwalde Damm Lenz STETTIN Podejuch Greifenberg Pyritz Baln Derzow Linde Königsberg Soldin Barlinchin Arnswalde Landsberg Custrin Reetz Ebertswalde Oderberg Freienwalde Wriezen Werneuchen Strausberg Protzel Seelow Lebus Drossen Zielentzig Frankfort Lagow Sternberg Schwiebus Crossen Zullichau Beeskow Buckow Müllrose Storkow Fürstenwalde Vogelsdorf Munchenberg Sonnenburg Königswald Schwerin Burg Brandenburg Gerdkin Lehnin Potsdam Koppnick Zehlendorf BERLIN Spandau Charlottenburg Tempelhof Landsberg Wusterhausen Mittenwalde Trebbin Belitz Buchholz Baruth Juterbogk Kemlitz Dahme Zahna Wittenberg Schonwald Luckau Lubben Peitz Cottbus Vetschau Kalau Dobern Drebkau Forsta Sprembeg Senftenberg Muskau Priebus Hoyerswerda Elsterwerda Mühlberg Torgau Pretzsch Herzberg Prettin Jessen Bitterfeld Dommitzsch Torna Ubigau Dobritzhugk Delitzsch Eilenburg Halle Saale Landsberg Merseburg LEIPZIG Lutzen Weissenfels Naumburg Zeitz Tzschern Stossen Flatz Crossen Jena Weimer Erfurth Gotha Eisenach Suhl Meiningen Schleusingen Posneck Saalfeld Rudolstadt Arnstadt Ilmenau Ohrdruf Gotha Tanger Munde Wust Tremmen Nauen Rathenau Havelberg Genthin Burg Loburg Belzig Rabenstein Brandenburg Gommern Wanzleben Magdeburg Hohenziatz Cotzow Hohenseiz Madern Schonbeck Barby Calbe Bernburg Cothen Dessau Aschersleben Sandersleben Hornburg Osterwyck Gronningen Halberstadt Quedlinburg Wernigerode The Harz Gottingen Osterode Herzberg Lauterberg Northeim Einbeck Alfeld Hildesheim Seesen Wolfenbuttel Brunswick Helmstadt Kolmirstadt Haldensleben Obisfelde Gardelegen Vorsfelde Wolmirstedt Stendal Tangermunde Arendsee Osterburg Seehausen Werben Kyritz Wusterhausen Neuruppin Gransee Templin Prenzlow Pasewalk Strasburg Anclam Usedom Wollin Gr. Haff L. Haff Ueckermunde Ferdinandsdorf Pyritz Greifenhagen Schwedt Angermunde Prenzlow Templin Lychen Gransee Ruppin Wittstock Gadow Glinow Perleberg Pritzwalk Meienburg Neustadt Lubz Strelitz Neubrandenburg Malchin Demmin Loitz Griefswald Wolgast Lassan Usedom Wollin Ueckermunde Anclam Ducherow Treptow Letzin Maldin Wismar Lubeck HAMBURG Schwerin Ratzeburg Boitzenburg Lenzen Nebelm Wittstock Havelberg Seehausen Kyritz Werben Arendsee Osterburg Salzwedel Giesekau Stendal Tangermunde Quarnebeck Deetz Tanger Munde Wust Tremmen Nauen Rathenau Havelberg Genthin Burg Loburg Belzig Rabenstein Brandenburg Gommern Wanzleben Magdeburg Hohenziatz Cotzow Hohenseiz Madern Schonbeck Barby Calbe Bernburg Cothen Dessau Aschersleben Sandersleben Hornburg Osterwyck Gronningen Halberstadt Quedlinburg Wernigerode The Harz Gottingen Osterode Herzberg Lauterberg Northeim Einbeck Alfeld Hildesheim Seesen Wolfenbuttel Brunswick Helmstadt Kolmirstadt Haldensleben Obisfelde Gardelegen Vorsfelde HANOVER

R. Elbe R. Aller R. Saal R. Oder R. Elbe R. Elbe

10 11 12 13 14 15 Longitude East

PRUSSIA

For the Rhenish Provinces which form part of Prussia, see Map of Northern Germany.

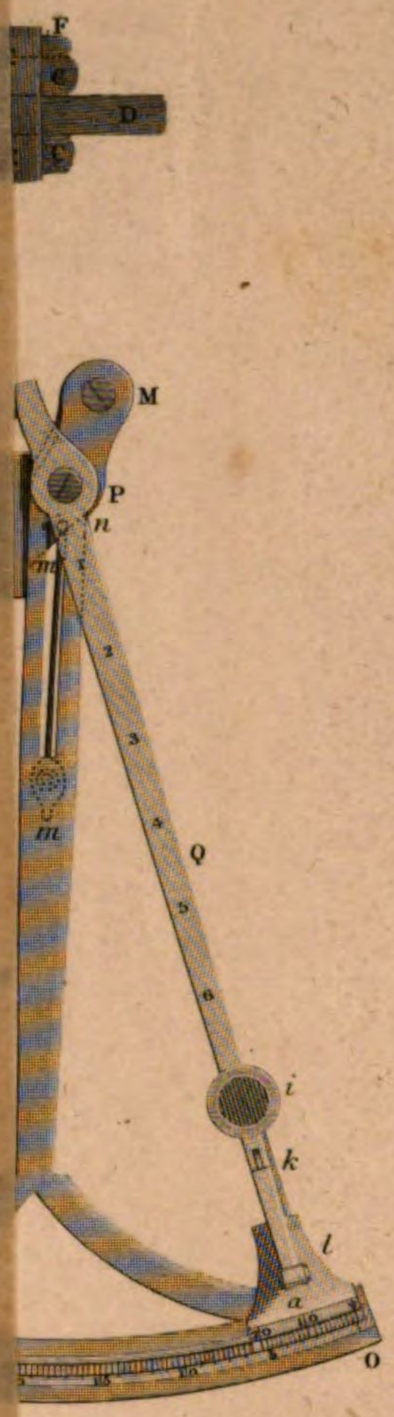
English Miles.

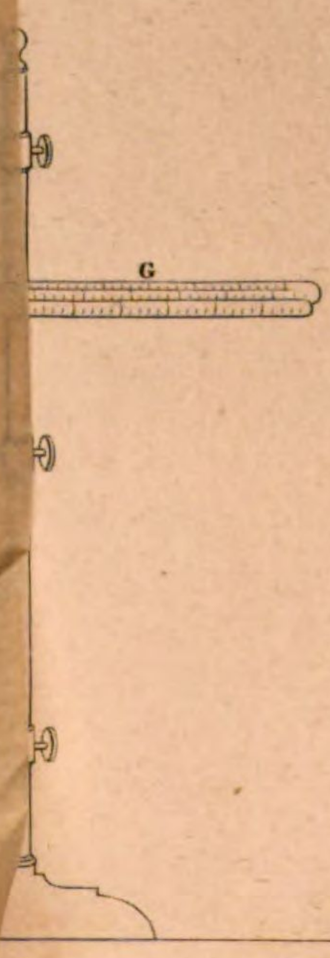
5 10 20 40 60 80 100

16 from Greenwich. 17 18 19 20 21 22

55 54 53 52 51 50

Engraved by S. Hall Bury St.t Bloomsb.y





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PYROMETER.

PLATE CCCCXIX.

Fig. 1.

Fig. 2.

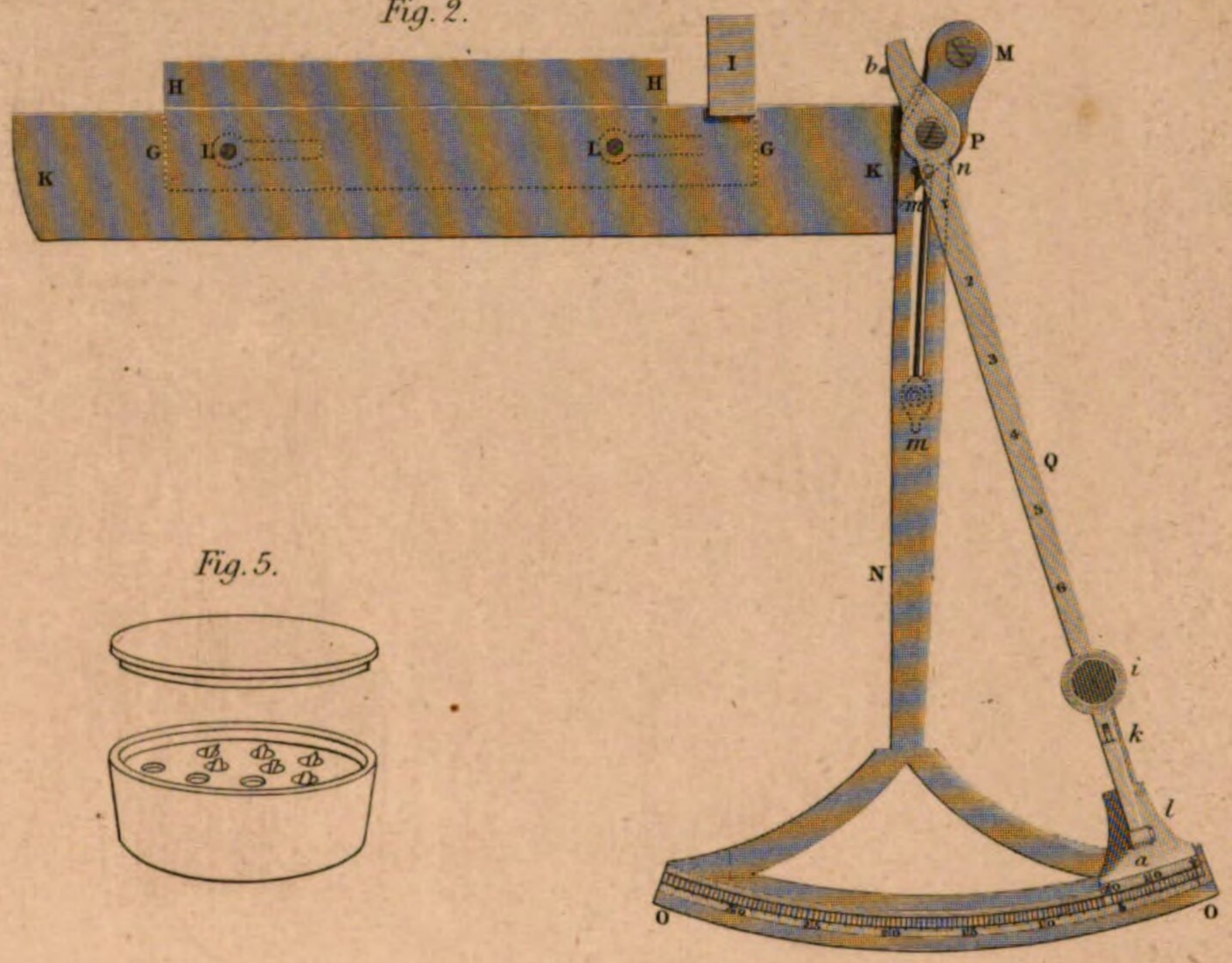


Fig. 3.

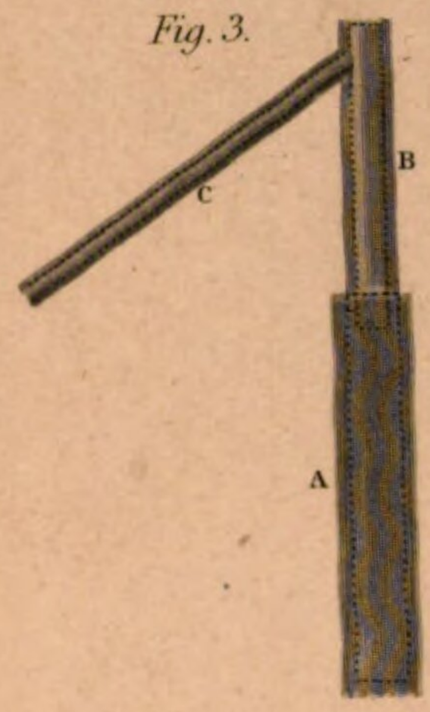
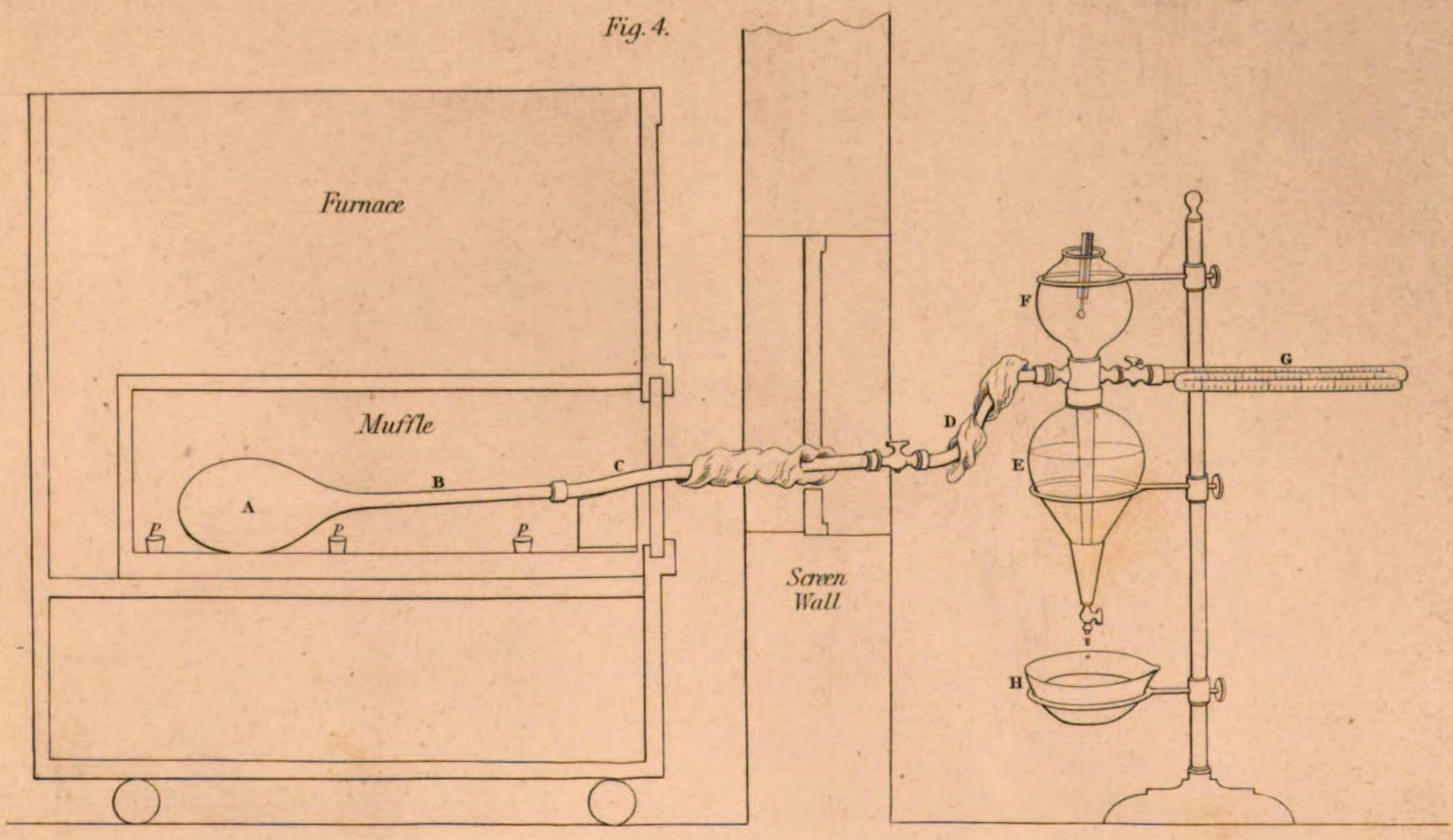


Fig. 5.

Fig. 4.



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MDZ Münchener DigitalisierungsZentrum Digitale Bibliothek

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